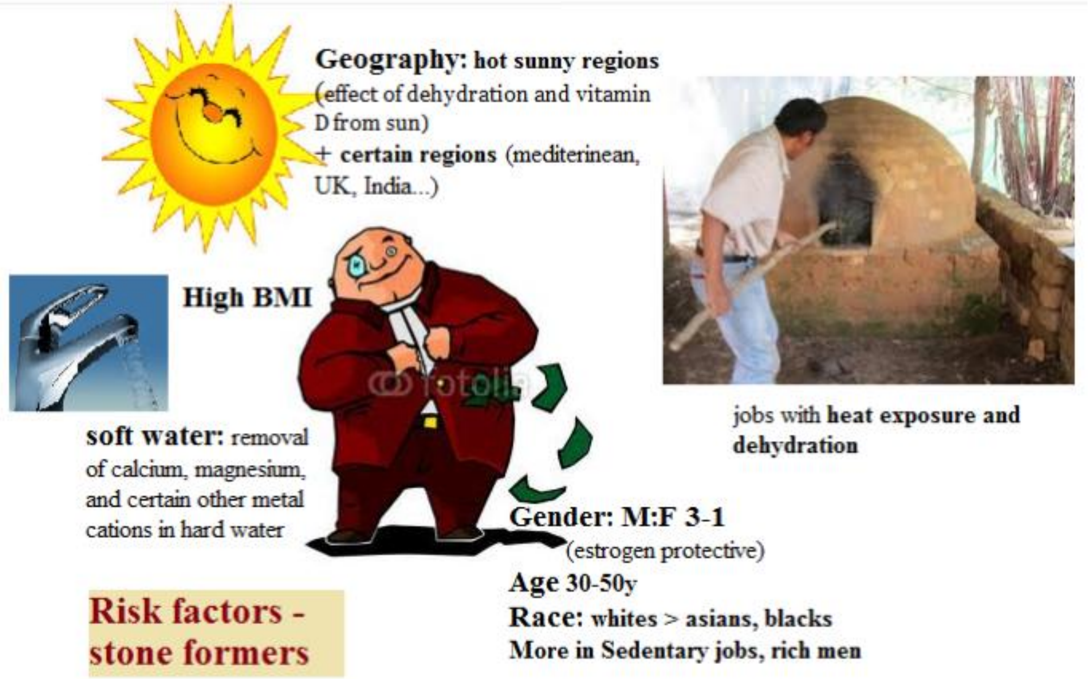
Urolithiasis

Incidence

- **lifetime prevalence is 1-10% (25% have +ve family hx)**
- **recurrence rate without Rx } 10% at 1yr, 50% at 10yrs**

Risk Factors:



Geography: hot sunny regions (effect of dehydration and vitamin D from sun)
+ **certain regions** (mediterinean, UK, India...)

High BMI

jobs with **heat exposure and dehydration**

soft water: removal of calcium, magnesium, and certain other metal cations in hard water

Gender: M:F 3-1 (estrogen protective)
Age 30-50y
Race: whites > asians, blacks
More in Sedentary jobs, rich men

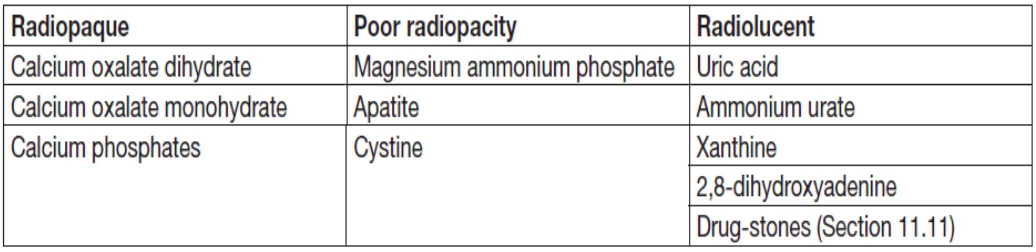
Risk factors - stone formers

Classification of stones

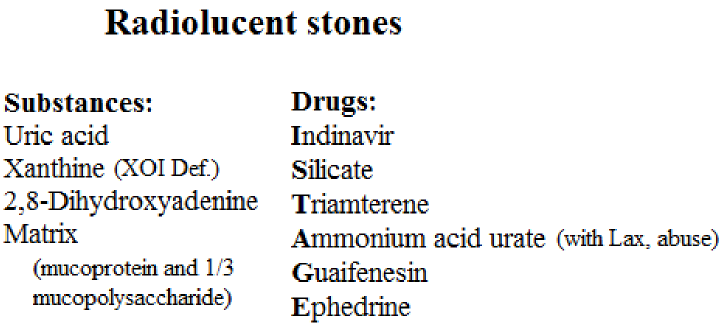
classified according to: Size, location, X-ray chch.,…

Acc to X-ray characteristics

- according to **plain X-ray appearance** (varies according to mineral composition).
- **Non-contrast-enhanced computer tomography (NCCT)** according to density and composition.



Radiopaque	Poor radiopacity	Radiolucent
Calcium oxalate dihydrate	Magnesium ammonium phosphate	Uric acid
Calcium oxalate monohydrate	Apatite	Ammonium urate
Calcium phosphates	Cystine	Xanthine
		2,8-dihydroxyadenine
		Drug-stones (Section 11.11)



Radiolucent stones

Substances:	**Drugs:**
Uric acid	Indinavir
Xanthine (XOI Def.)	Silicate
2,8-Dihydroxyadenine	Triamterene
Matrix	Ammonium acid urate (with Lax, abuse)
(mucoprotein and 1/3 mucopolysaccharide)	Guaifenesin
	Ephedrine

Classification acc. to stone composition:

a) Ca-containing (75%)

- Ca oxalate (60%) } COM (whewellite)
- Ca oxalate dihvdrate (weddellite)
- mixed Ca oxalate + hydroxvapatite (20%)
- Ca P04 (brushite) (2°o)

b) non-Ca stones (5%)

- uric acid(°o)
- Mg NH4 P04 (struvite) (7%)
- cystine (2%)
- matrix (<i%)
- 2,8-dihvdroxvadenine (<a%)
- medication related: triameterene, silica, indinavir (<1% each), etc

Table 5: Stone composition

قراءة سريعة شفوى

Chemical name	Mineral name	Chemical formula
Calcium oxalate monohydrate	Whewellite	$CaC_2O_4.H_2O$
Calcium oxalate dihydrate	Wheddelite	$CaC_2O_4.2H_2O$
Basic calcium phosphate	Apatite	$Ca_{10}(PO_4)_6.(OH)_2$
Calcium hydroxyl phosphate	Hydroxylapatite	$Ca_5(PO_3)3(OH)$
b-tricalcium phosphate	Whitlockite	$Ca_3(PO4)_2$
Carbonate apatite phosphate	Dahllite	$Ca_5(PO4)_3OH$
Calcium hydrogen phosphate	Brushite	$CaHPO_4.2H_2O$
Calcium carbonate	Aragonite	$CaCO_3$
Octacalcium phosphate		$Ca_8H_2(PO_4)_6 . 5H_2O$
Uric acid dihydrate	Uricite	$C_5H_4N_4O_3$
Ammonium urate		$NH_4C_5H_3N_4O_3$
Sodium acid urate monohydrate		$NaC_5H_3N_4O_3. H_2O$
Magnesium ammonium phosphate	Struvite	$MgNH_4PO_4.6H_2O$
Magnesium acid phosphate trihydrate	Newberyite	$MgHPO_4. 3H_2O$
Magnesium ammonium phosphate monohydrate	Dittmarite	$MgNH_4(PO_4) . 1H_2O$
Cystine		$[SCH_2CH(NH_2)COOH]_2$
Gypsum	Calcium sulphate dihydrate Zinc phosphate tetrahydrate	$CaSO_4.2 H_2O$ $Zn_3(PO_4)_2.4H_2O$
Xanthine		
2,8-dihydroxyadenine		
Proteins		
Cholesterol		
Calcite		
Potassium urate		
Trimagnesium phosphate		
Melamine		
Matrix		
Drug stones	• Active compounds crystallising in urine • Substances impairing urine composition (Ch. 11.11)	
Foreign body calculi		

DIAGNOSIS

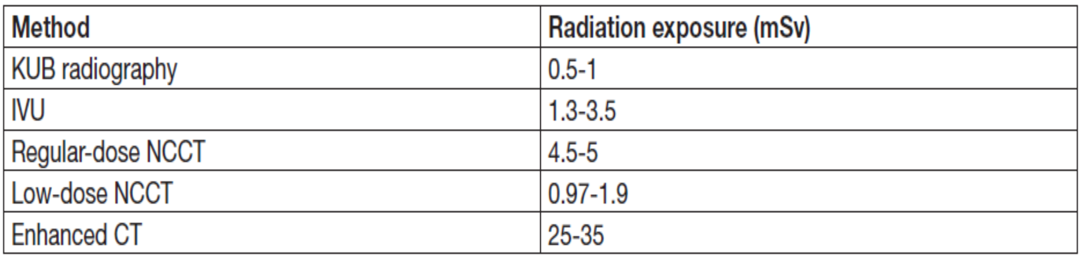
Diagnostic imaging

1. Detailed medical history and physical examination.
2. Symptoms:
    - ***loin pain, vomiting***, +/- ***fever***,
    - or ***asymptomatic***.
3. Imaging:
    - **ultrasonography (US) (the primary diagnostic tool):**
        - US is safe (no radiation), and inexpensive.
        - Identify stones located in the calices, pelvis, and pyeloureteric and vesicoureteric junctions, as well as in patients with upper urinary tract dilatation.
        - For stones > 5 mm, sensitivity of 95% and specificity near 100%
    - **KUB :**
        - The sensitivity and specificity (60% and 85%)
        - KUB should not be performed if NCCT is considered,
        - differentiate radiolucent and radiopaque stones.
    - **NCCT**
        - become the standard for diagnosing acute flank pain, and has replaced intravenous urography (IVU)
        - CT Findings suggest ureteral obstruction
            - Hydronephrosis
            - Hydroureter
            - peri-ureteric stranding
            - UVJ edema

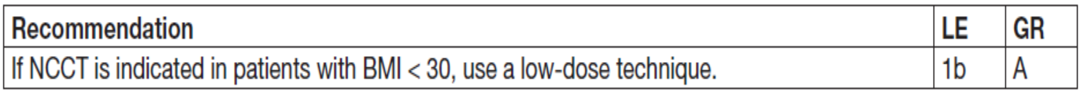
Evaluation of patients with acute flank pain

- NCCT (standard) replaced (IVU)
- Adv:
  - When stones are absent, can identify the cause of abdominal pain.
  - NCCT shows higher sensitivity and specificity for identifying urinary stones than IVP.
  - NCCT detect uric acid and xanthine stones (radiolucent), but **not indinavir stones**.
  - NCCT can determine stone density, inner structure of the stone and skin-to-stone distance; all of which affect extracorporeal shock wave lithotripsy (SWL) outcome.
- Disadv:
  - More expensive
  - loss of information about renal function and urinary collecting system anatomy, as well as higher radiation dose.
  - Radiation risk (>IVP) can be reduced by **low-dose CT**.
    - In patients with body mass index (BMI) < 30, low-dose CT has sensitivity of 85% for detecting ureteric stones < 3 mm and 100% for calculi > 3 mm.
  - Confuse with phlebolith

Table 8: Radiation exposure of imaging modalities (19-22)



Method	Radiation exposure (mSv)
KUB radiography	0.5-1
IVU	1.3-3.5
Regular-dose NCCT	4.5-5
Low-dose NCCT	0.97-1.9
Enhanced CT	25-35



Recommendation	LE	GR
If NCCT is indicated in patients with BMI < 30, use a low-dose technique.	1b	A

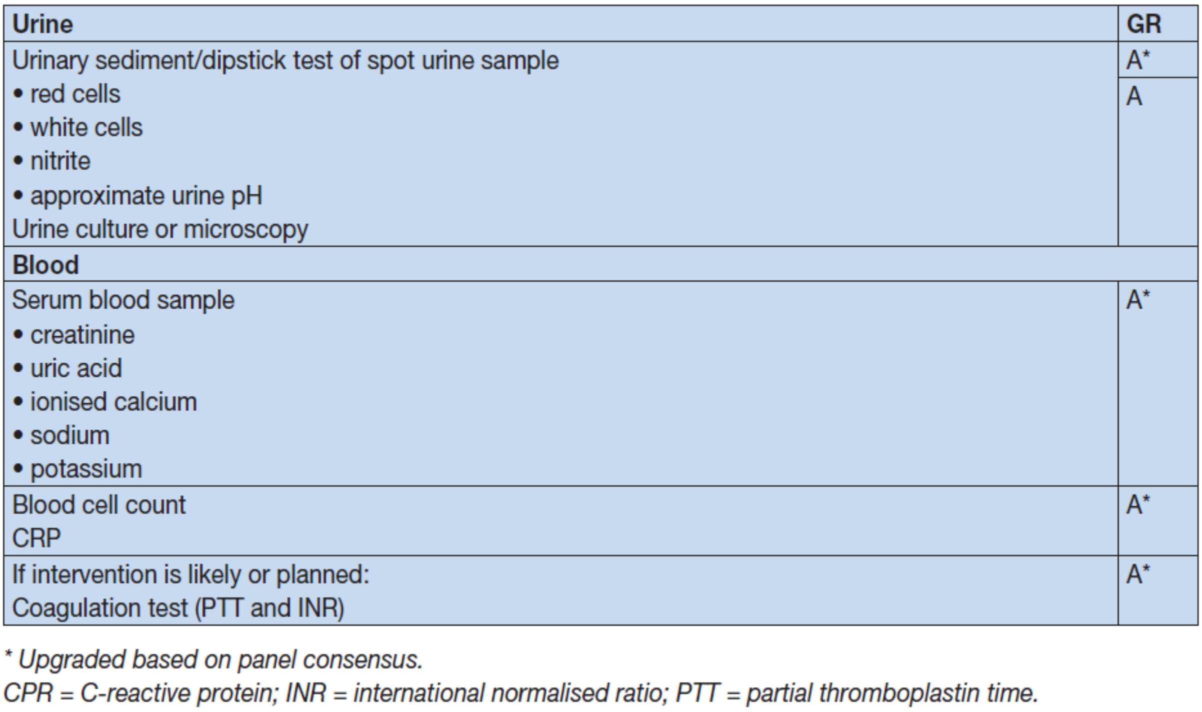
Evaluation of patients for whom further treatment of renal stones is planned:

- A contrast study is recommended if stone removal is planned and the anatomy of the renal collecting system needs to be assessed.
- Enhanced CT is preferable because it enables 3D reconstruction of the collecting system, as well as measurement of stone density and skin-to-stone distance. IVU may also be used.

4. Metabolic work-up:

emergency patient with urolithiasis needs a biochemical work-up of urine and blood besides imaging. At that point, no distinction is made between high- and low-risk patients.

Basic laboratory analysis - **emergency** urolithiasis patients



Urine	**GR**
Urinary sediment/dipstick test of spot urine sample	A*
• red cells • white cells • nitrite • approximate urine pH Urine culture or microscopy	A
Blood	
Serum blood sample • creatinine • uric acid • ionised calcium • sodium • potassium	A*
Blood cell count CRP	A*
If intervention is likely or planned: Coagulation test (PTT and INR)	A*

** Upgraded based on panel consensus.*
CPR = C-reactive protein; INR = international normalised ratio; PTT = partial thromboplastin time.

Basic laboratory analysis - **non-emergency** urolithiasis patients

- if no intervention is planned, examination of **sodium, potassium, CRP**, and **blood coagulation time** can be omitted.
- Only patients at high risk for stone recurrence →specific analytical programme.
- The easiest means to achieve correct diagnosis is by analysis of a passed stone using a valid method. Once mineral composition is known, the potential metabolic disorders can be identified.

Analysis of stone composition

- performed in all first-time stone formers.
- repeat stone analysis is needed in case of:
  - recurrence under pharmacological prevention;
  - early recurrence after interventional therapy with complete stone clearance;
  - late recurrence after a prolonged stone-free period.
- The best analytical procedures are **infrared spectroscopy (IRS)** or **X-ray diffraction (XRD)**. Others are ***polarisation microscopy***, and Chemical analysis (wet chemistry) obsolete.

Treatment of urolithiasis

Renal colic

Symptoms & signs:

- acute onset flank pain +/- radiating to lower abdomen/groin/testicle/labia
- CVA tenderness
- storage LUTS
- no improvement with movement or positioning
- N/V (celiac plexus)
- Tachycardia, elevated BP (non-specific)
- low grade fever

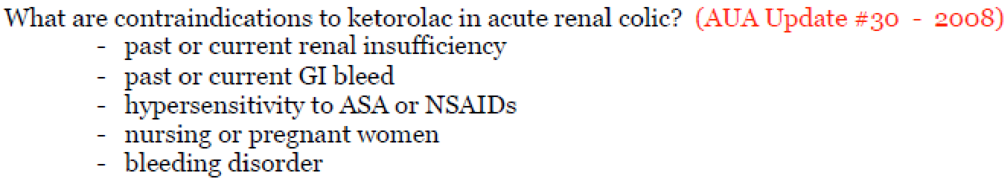
lab investigations

- mild leukocvtosis (<15.000/mm2)
- mildly elevated BUN and/or creatinine (bilateral stone, solitary kidney, dehydration)
- hypoK (vomiting)
- microscopic hematuria (absence does NOT r/o stone)
- mild pyuria

Pain relief

- **the first therapeutic step in patients with an acute stone colic.**
    - **Non-steroidal anti-inflammatory drugs (NSAIDs)** better analgesic efficacy than opioids.

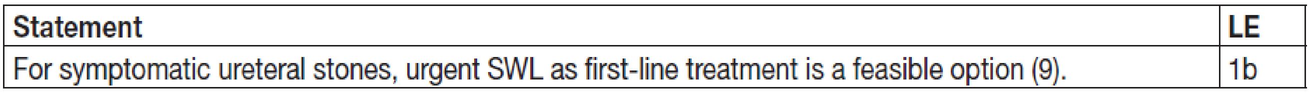
      (less likely to require further analgesia in the short term).



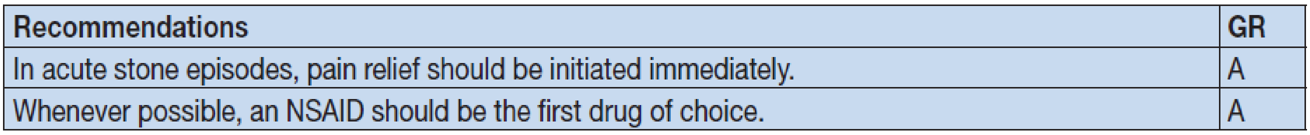
What are contraindications to ketorolac in acute renal colic? (AUA Update #30 - 2008)

- past or current renal insufficiency
- past or current GI bleed
- hypersensitivity to ASA or NSAIDs
- nursing or pregnant women
- bleeding disorder

    - **Opioids, *particularly pethidine***, associated with a high rate of vomiting > NSAIDs, greater likelihood of further analgesia being needed (recommended that it is not pethidine).



Statement	**LE**
For symptomatic ureteral stones, urgent SWL as first-line treatment is a feasible option (9).	1b



Recommendations	**GR**
In acute stone episodes, pain relief should be initiated immediately.	A
Whenever possible, an NSAID should be the first drug of choice.	A

Prevention of recurrent renal colic

- Facilitation of passage of ureteral stones (section 5.3).
- ***NSAID tablets or suppositories*** (e.g., diclofenac sodium, 100-150 mg/day, 3-10 days) if ureteral stones expected to pass spontaneously. It may help to reduce inflammation and risk of recurrent pain.
    - Although diclofenac can affect renal function in patients with already reduced function, it has no effect in patients with normal kidney function.
- ***α-blockers***, Daily, reduce recurrent colic.
- ***Drainage***,
    - If analgesia cannot be achieved medically,
    - using stenting or percutaneous nephrostomy, or stone removal, should be performed.

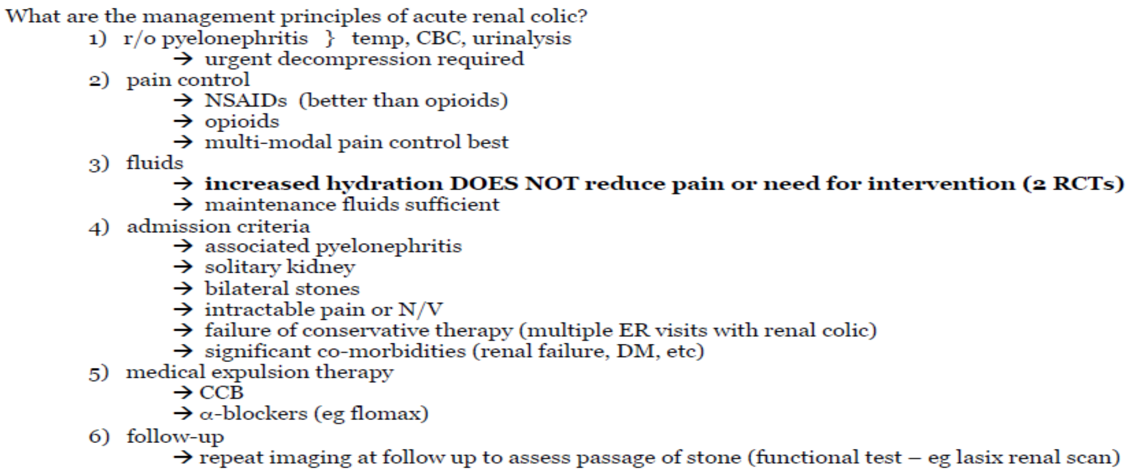
*4.1.3 **Recommendations for analgesia during renal colic***

First choice: start with an NSAID, e.g. diclofenac*, indomethacin or ibuprofen**.

Second choice: hydromorphine, pentazocine or tramadol.

Use α-blockers to reduce recurrent colics.

**Affects glomerular filtration rate (GFR) in patients with reduced renal function (15) (LE: 2a). **Recommended to counteract recurrent pain after ureteral colic.*


What are the management principles of acute renal colic?

1) r/o pyelonephritis } temp, CBC, urinalysis
    - → urgent decompression required
2) pain control
    - → NSAIDs (better than opioids)
    - → opioids
    - → multi-modal pain control best
3) fluids
    - → **increased hydration DOES NOT reduce pain or need for intervention (2 RCTs)**
    - → maintenance fluids sufficient
4) admission criteria
    - → associated pyelonephritis
    - → solitary kidney
    - → bilateral stones
    - → intractable pain or N/V
    - → failure of conservative therapy (multiple ER visits with renal colic)
    - → significant co-morbidities (renal failure, DM, etc)
5) medical expulsion therapy
    - → CCB
    - → α-blockers (eg flomax)
6) follow-up
    - → repeat imaging at follow up to assess passage of stone (functional test – eg lasix renal scan)

Management of sepsis in obstructed kidney

- The obstructed kidney with signs of UTI is a **urological emergency**.
- ***Urgent decompression*** is often necessary to:
    - prevent further complications in infected hydronephrosis secondary to stone-induced, unilateral or bilateral renal obst.
    - Decompression → delivery of antibiotics to obst. kidney.

4.2.1 ***Decompression***

- two urgent options:
    - indwelling ureteral catheter;
    - percutaneous nephrostomy catheter.
- There is little evidence to support the superiority of percutaneous nephrostomy over retrograde stenting for primary treatment of infected hydronephrosis.
- Definitive stone removal should be delayed until the infection is cleared following a complete course of antimicrobial therapy.
- ***Emergency nephrectomy*** may become necessary in highly complicated cases to eliminate further complications.

Further measures

- Following urgent decompression → **both urine- and blood samples for culture-antibiogram sensitivity testing**,
- Antibiotics initiated then adjusted later according to culture.

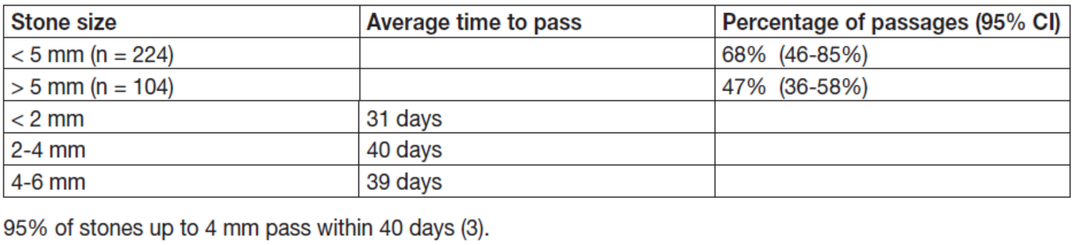
Stone Relief

Observation of ureteral stones

Stone-passage rates

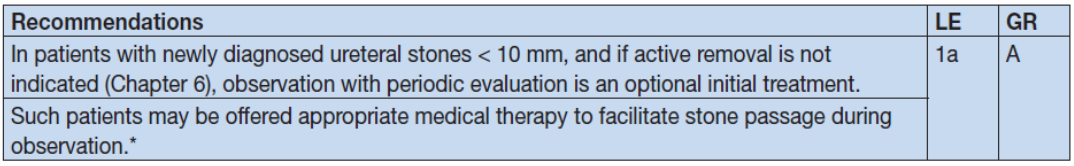
- spontaneous stone passage according to size.

Likelihood of ureteral stone passage of ureteral stones



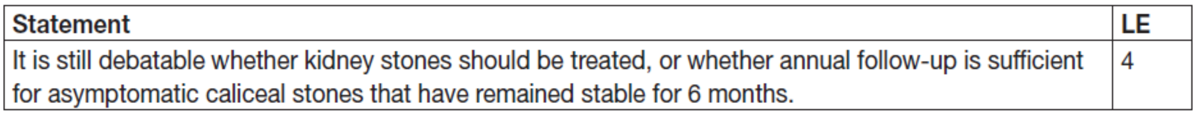
Stone size	Average time to pass	Percentage of passages (95% CI)
< 5 mm (n = 224)		68% (46-85%)
> 5 mm (n = 104)		47% (36-58%)
< 2 mm	31 days	
2-4 mm	40 days	
4-6 mm	39 days	

95% of stones up to 4 mm pass within 40 days (3).

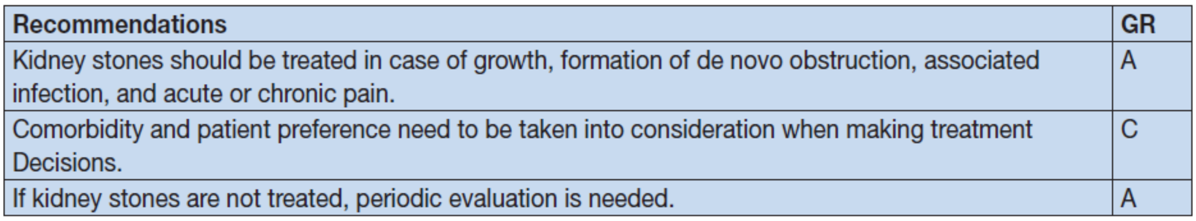


Recommendations	LE	GR
In patients with newly diagnosed ureteral stones < 10 mm, and if active removal is not indicated (Chapter 6), observation with periodic evaluation is an optional initial treatment.	1a	A
Such patients may be offered appropriate medical therapy to facilitate stone passage during observation.*		

Observation of renal stones:



Statement	LE
It is still debatable whether kidney stones should be treated, or whether annual follow-up is sufficient for asymptomatic caliceal stones that have remained stable for 6 months.	4



Recommendations	GR
Kidney stones should be treated in case of growth, formation of de novo obstruction, associated infection, and acute or chronic pain.	A
Comorbidity and patient preference need to be taken into consideration when making treatment Decisions.	C
If kidney stones are not treated, periodic evaluation is needed.	A

Medical expulsive therapy (MET)

- Drugs act by **relaxing ureteral smooth muscle** *through* ***inhibition of calcium channel pumps*** or ***α-1 receptor blockade***.

- patients with ureteral stones or ESWL fragments treated with α-blockers or nifedipine → more likely to pass stones & fewer episodes of colic.

Medical agents

- **Alpha Blokers:**
  - Tamsulosin is one of the most commonly used α-blockers.
  - **tamsulosin, terazosin and doxazosin** are equally effective.
- **Calcium-channel blockers**:
  - only nifedipine has been investigated.
- Administration of **tamsulosin and nifedipine** is safe and effective in patients with distal ureteral stones with renal colic (tamsulosin is significantly better than nifedipine in relieving renal colic and facilitating and accelerating ureteral stone expulsion).
- Use of **corticosteroids** in combination **with α-blockers** in MET can be made.

Factors affecting success of MET (tamsulosin):

Stone size

- ~5 mm→ increase the stone-free rate (SFR).
- Proximal 5-10 mm: encourage stone migration to a more distal part

Stone location

- Best with distal ureteral stones.

Medical expulsive therapy after (ESWL)

- Fasten expulsion,increase SFRs and reduce analgesic requirements.

Medical expulsive therapy after ureteroscopy

- following holmium:YAG laser lithotripsy increases SFRs and reduces colic episodes.

Medical expulsive therapy and ureteral stents

Duration of MET treatment

- about 1 month.

Chemolytic dissolution of stones

- Oral or percutaneous irrigation chemolysis can be useful **1st line ttt**or adjunct to SWL, PNL, URS or open surgery → elimination of small residual fragments.
- **Combined treatment with SWL and chemolysis**: minimally invasive option for patients with partial or complete infection staghorn stones who are not eligible for PNL.
- Stone fragmentation → increased stone surface area → improved efficacy of chemolitholysis.
- Chemolysis is possible only for the stone compositions listed below, therefore (knowledge of stone composition is mandatory before treatment):

Percutaneous irrigation chemolysis

- may be an option for infection- and uric acid stones.
- Better use pressure and flow control.
- Either 2 nephrostomies or one with JJ stent.

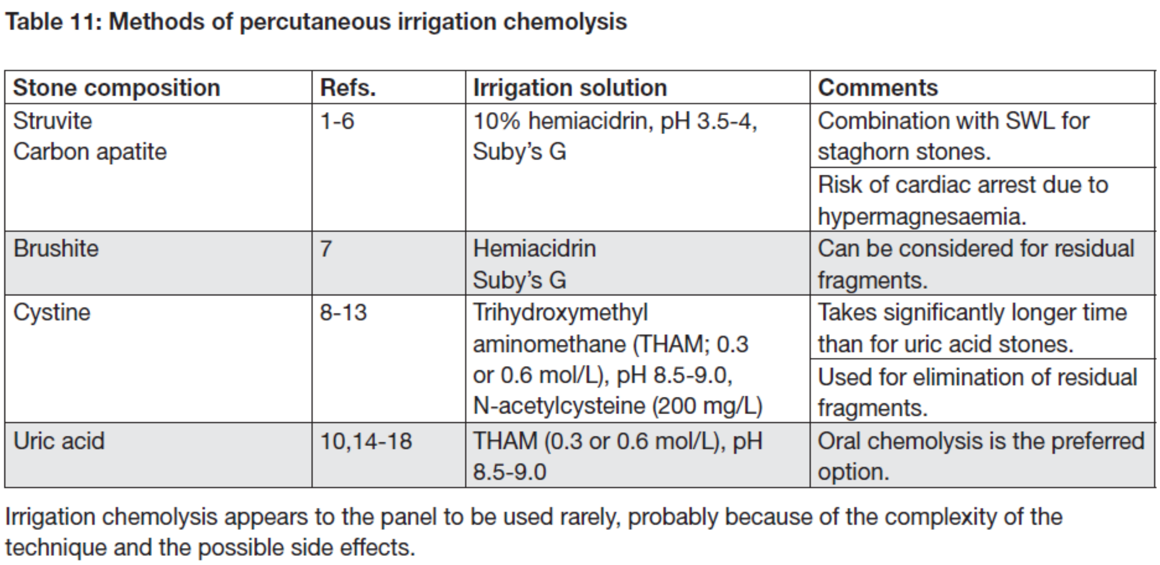


Table 11: Methods of percutaneous irrigation chemolysis

Stone composition	Refs.	Irrigation solution	Comments
Struvite Carbon apatite	1-6	10% hemiacidrin, pH 3.5-4, Suby's G	Combination with SWL for staghorn stones. Risk of cardiac arrest due to hypermagnesaemia.
Brushite	7	Hemiacidrin Suby's G	Can be considered for residual fragments.
Cystine	8-13	Trihydroxymethyl aminomethane (THAM; 0.3 or 0.6 mol/L), pH 8.5-9.0, N-acetylcysteine (200 mg/L)	Takes significantly longer time than for uric acid stones. Used for elimination of residual fragments.
Uric acid	10,14-18	THAM (0.3 or 0.6 mol/L), pH 8.5-9.0	Oral chemolysis is the preferred option.

Irrigation chemolysis appears to the panel to be used rarely, probably because of the complexity of the technique and the possible side effects.

Oral chemolysis

- Oral chemolitholysis is **efficient only for uric acid calculi**,

- based on alkalinisation of urine by application of **alkaline citrate or sodium bicarbonate** (PH **6.5-7.2)which** might lead to calcium phosphate stone formation.
- In case of uric acid obstruction of the collecting system, oral chemolysis in combination with urinary drainage is indicated.
- A ***combination of alkalinisation with tamsulosin*** seems to achieve the highest SFRs for distal ureteral stones.

Contraindications to dissolution therapy:

1. active infection
2. flank pain, distal obstruction,
3. electrolyte abn., renal insufficiency
4. fever
5. immature tract

Complications of urinary alkalinization:

- CaPO4 stones, struvite stones
- volume overload (Na HCO3)
- hyperK (K citrate)
- GI upset, flatulence

Side effects of renacidin? - now BANNED

General: death (likely d/t sepsis), Perc tract related complication (bleed. Collecting system injury, pain, persistent drainage, extravasation)

Renacidin specific: Neuro, BP, apnea, met acidosis, mucosal irritation

Extracorporeal shock wave lithotripsy (SWL)

- in the early 1980s
- Stone localization (U/s alone , fluoroscopy alone or both).

Contraindications of ESWL:

absolute

1) **H**abitus (obesity, orthopedic deformities)
2) **P**regnancy

Urologic

3) **O**bstruction distally
4) **UTI**

CVS

5) **C**oagulopathy
6) **HTN** uncontrolled
7) **C**alcified renal artery aneurysm or AAA

relative

8) large stone burden
9) certain stone types } cystine, COM, matrix
10) certain anatomic features } horseshoe kidney, calyceal tic, ectopic kidney

N.B:

- **Kids can get Eswl, but cover lungs to avoid contusion.**
- **Bilateral can be done → better stent at least one side**

Stenting before carrying out extracorporeal shock wave lithotripsy

Stenting in kidney stones

- **Routine use of internal stents before SWL does not improve SFR**.
- **A JJ stent reduces the risk of renal colic and obstruction**, but does not reduce formation of steinstrasse or infective complications.
- prevents obstruction and loss of ureteral contractions.
- May increase the risk of obstructive pyelonephritis. ***If fever*** occurs and lasts for a few days despite proven correct stent position**, *the stent must be removed*** and replaced by a JJ stent ***or a perc. nephrostomy***.

Stenting in ureteral stones

- routine stenting is not recommended as part of SWL.

Best clinical practice

Pacemaker

- can be treated with SWL, provided that appropriate technical precautions are taken; patients with implanted cardioverter defibrillators must be managed with special care (***firing mode temporarily reprogrammed during SWL treatment***).

Shock wave rate

- Lowering shock wave frequency from 120 to 60-90 shock waves/min improves SFR. Tissue damage increases with shock wave frequency. The optimal shock wave frequency is 1.0-1.5 Hz

Number of shock waves, energy setting and repeat treatment sessions

- ***Starting SWL on a lower energy setting*** with **stepwise power** (and SWL sequence) ramping can achieve vasoconstriction during treatment, which prevents renal injury with better SFRS (96% vs. 72%),
- no difference has been found for fragmentation or evidence of complications after SWL.
- repeat sessions are feasible (within 1 day for ureteral stones).

Improvement of acoustic coupling

- Proper acoustic coupling between the cushion of the treatment head and the patient's skin using U/S gel.
- Defects (air pockets) in the coupling gel reflect 99% of shock waves and reduces stone fragmentation by 20-40%.
- To reduce air pockets, the gel should be applied to the water cushion straight from the container, rather than by hand.

Pain control

- to limit pain-induced movements & excessive respiratory excursions

Antibiotic prophylaxis

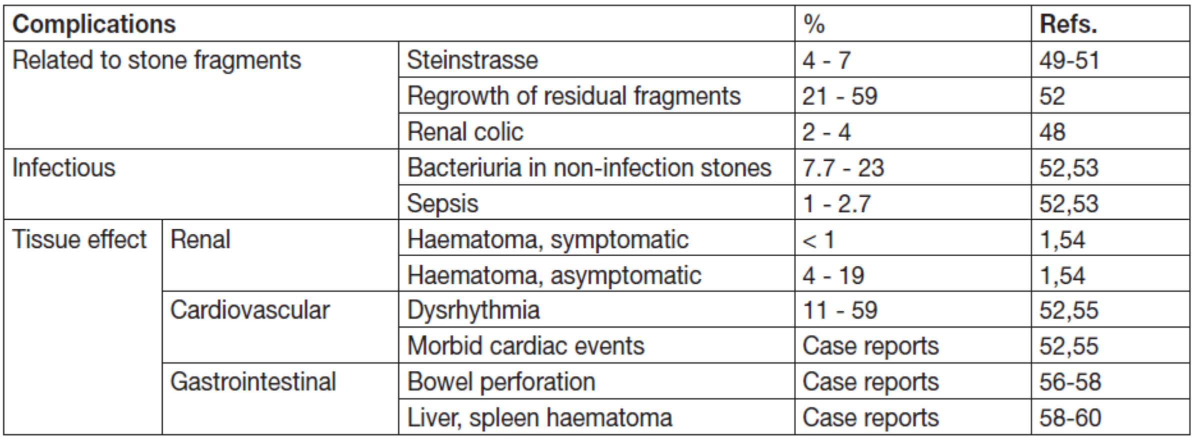
- No standard antibiotic prophylaxis before SWL is recommended.
- recommended in: internal stent placement and in the presence of increased bacterial burden (e.g., indwelling catheter, nephrostomy tube, or infectious stones).

Medical expulsive therapy after extracorporal shock wave lithotripsy

- increase expulsion and SFRs and reduce analgesic requirements.

Complications of extracorporeal shock wave lithotripsy

Compared to PNL and ureteroscopy, there are fewer overall complications with SWL (Table 12).

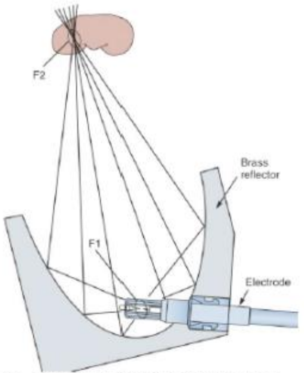


Complications			%	**Refs.**
Related to stone fragments		Steinstrasse	4 - 7	49-51
		Regrowth of residual fragments	21 - 59	52
		Renal colic	2 - 4	48
Infectious		Bacteriuria in non-infection stones	7.7 - 23	52,53
		Sepsis	1 - 2.7	52,53
Tissue effect	Renal	Haematoma, symptomatic	< 1	1,54
		Haematoma, asymptomatic	4 - 19	1,54
	Cardiovascular	Dysrhythmia	11 - 59	52,55
		Morbid cardiac events	Case reports	52,55
	Gastrointestinal	Bowel perforation	Case reports	56-58
		Liver, spleen haematoma	Case reports	58-60

Different types of SWL generators:

1) electrohydraulic (spark gap):

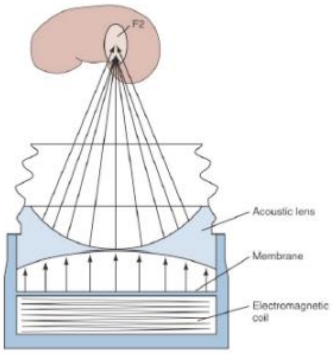
- spherically expanding **shockwave is generated by an underwater spark discharge**
- **electrode at F1 and stone at F2**
- reflector focuses shockwave energy at F2
- **eg Dornier HM3, HealthTronics Lithotron Ultra**



→ **ELECTROHYDRAULIC**

2) electromagnetic

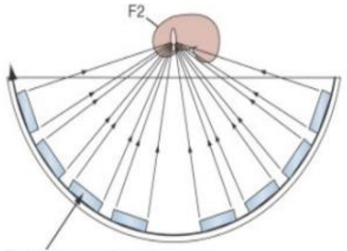
- plane or cylindrical **shockwaves generated by magnetic field** between electromagnetic coil conductors
- **only F2 }** acoustic lens (plane) or parabolic reflector (cylindrical) used to focus shockwave energy at F2
- eg Siemens Lithostar, Dornier DoLi



→ **ELECTROMAGNETIC**

3) piezoelectric

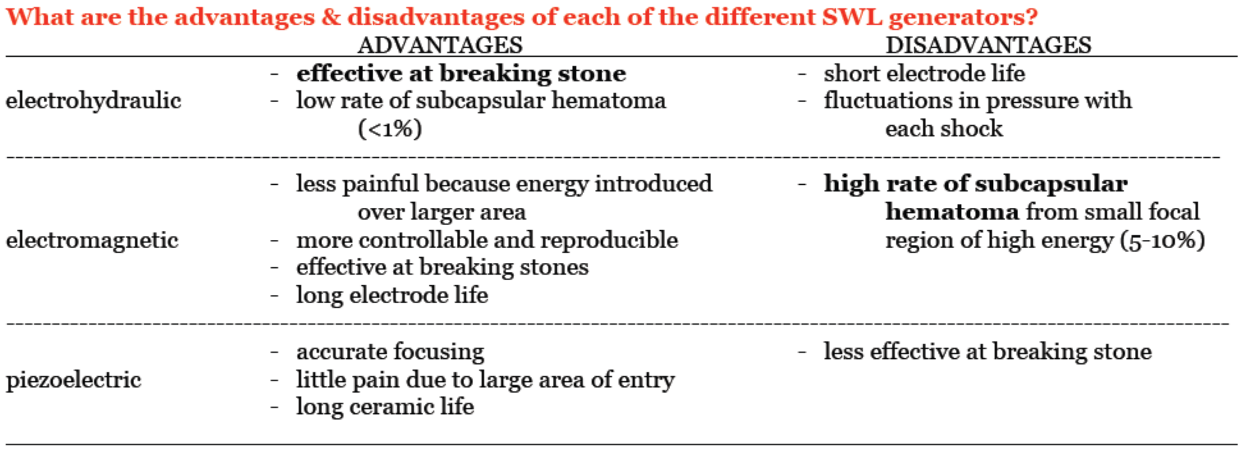
- plane **shockwaves generated by rapid expansion of ceramic elements**
- **only F2** } crystals are oriented in a spherical dish that focuses energy at F2
- eg Wolf P3000



→ **PIEZOELECTRIC**

4) other

- microexplosive lead azide generator
- laser beam generator
- multi-stage light gas gun generator



What are the advantages & disadvantages of each of the different SWL generators?

	ADVANTAGES	DISADVANTAGES
electrohydraulic	- **effective at breaking stone** - low rate of subcapsular hematoma (<1%)	- short electrode life - fluctuations in pressure with each shock
electromagnetic	- less painful because energy introduced over larger area - more controllable and reproducible - effective at breaking stones - long electrode life	- **high rate of subcapsular hematoma** from small focal region of high energy (5-10%)
piezoelectric	- accurate focusing - little pain due to large area of entry - long ceramic life	- less effective at breaking stone

How are stones fragmented:

stone breaks due to mechanical stresses produced either directly by incident shockwave or indirectly by collapse of cavitation bubble

Theories of stone fragmentation:

1) **Spall fracture:** shockwave enters then hits sites of impedence mismatch (eg distal surface), reflecting back, creating tensile (negative) wave that fractures stone
2) **Superfocusing**
3) **Shear stress**
4) **Compression (squeezing-splitting)**
5) **Acoustic cavitation 6) Dynamic fracture**

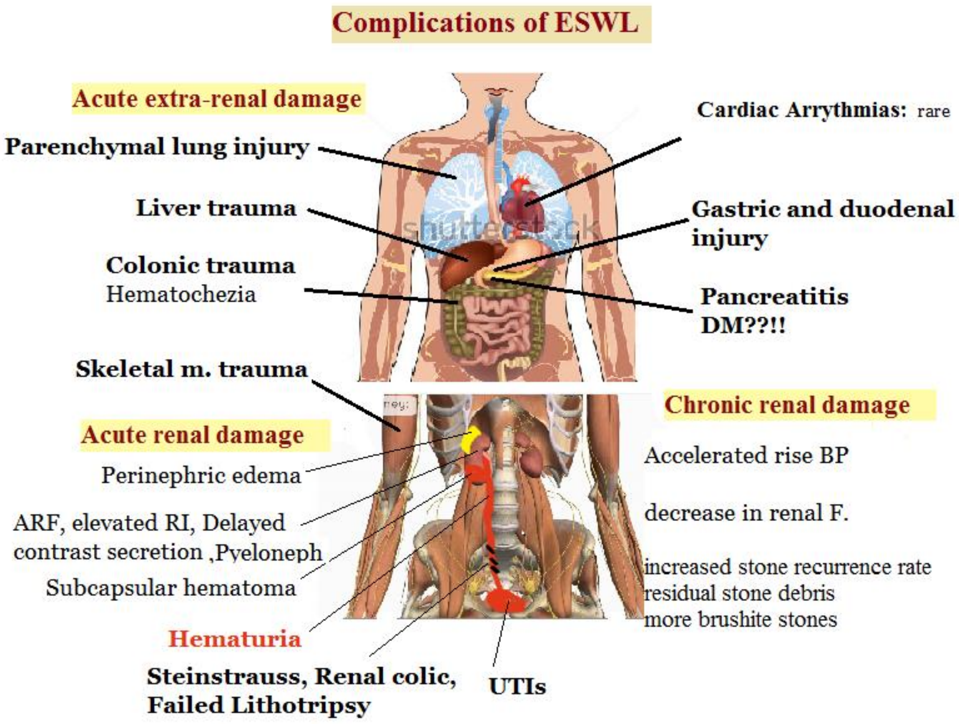
Stone types most resistant to SWL:

1) **cystine**
2) **CaPO4 (brushite)**
3) **COM**

treated with SWL if <1.5cm)
if more→ PNL or URS recommended

4) struvite
5) hydroxyapatite
6) Ca oxalate dihydrate
7) uric acid

Complications of Eswl:



Intracorporeal Lithotriptors

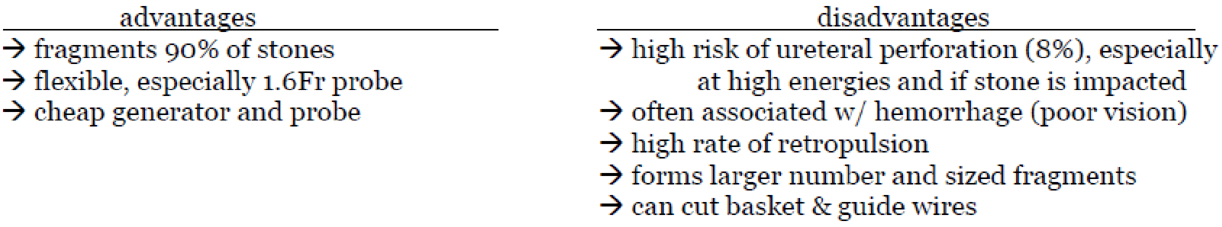
different types of intracorporeal lithotriptors?

1) **flexible**: EHL, laser
2) **rigid**: ballistic (pneumatic), ultrasound

EHL

Mech:

- underwater "spark plug" → explosive formation of plasma channel + vaporization of surrounding H2O
- expanding plasma causes hydraulic shockwave then formation of a cavitation bubble
- **Only non-contact lithotrite**



advantages	disadvantages
→ fragments 90% of stones	→ high risk of ureteral perforation (8%), especially at high energies and if stone is impacted
→ flexible, especially 1.6Fr probe	→ often associated w/ hemorrhage (poor vision)
→ cheap generator and probe	→ high rate of retropulsion
	→ forms larger number and sized fragments
	→ can cut basket & guide wires

laser

Light Amplification by Stimulated Emission of Radiation”

Mech:

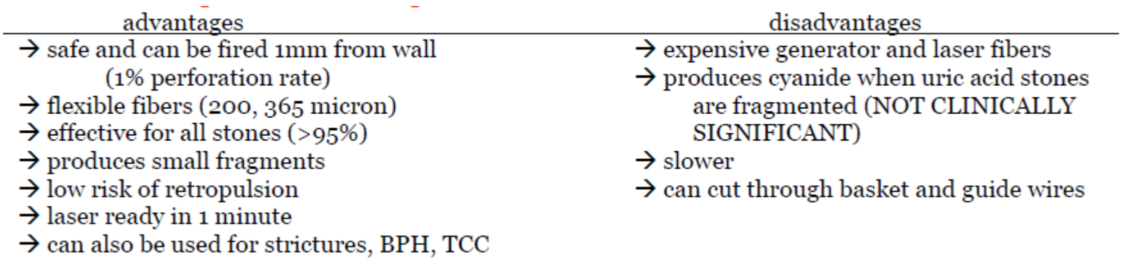
- energy stimulates an atom to produce excited electrons → releases light energy
- laser light is coherent (photons in phase), collimated (photons travel parallel), and monochromatic (photons have same wavelength) → transmission of [ ]’d energy

Types: (named after the laser medium generating specific wavelength)

1- **holmium:YAG laser** (2140nm):

1. longer pulse duration produces elongated cavitation bubble → generates only a weak shockwave
2. absorbed by water so little damage to surrounding tissue
3. zone of damage is 0.5 to 1.0mm
4. photothermal mechanism causes stone vaporization

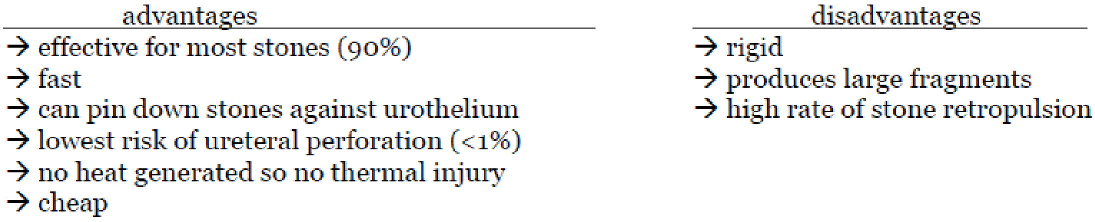
2- coumarin pulsed-dye laser (504nm)



advantages	disadvantages
→ safe and can be fired 1mm from wall (1% perforation rate)	→ expensive generator and laser fibers
→ flexible fibers (200, 365 micron)	→ produces cyanide when uric acid stones are fragmented (NOT CLINICALLY SIGNIFICANT)
→ effective for all stones (>95%)	→ slower
→ produces small fragments	→ can cut through basket and guide wires
→ low risk of retropulsion	
→ laser ready in 1 minute	
→ can also be used for strictures, BPH, TCC	

Ballistic lithotripsy

Mech: relies on the energy generated by the movement of a projectile (“jack-hammer effect”)

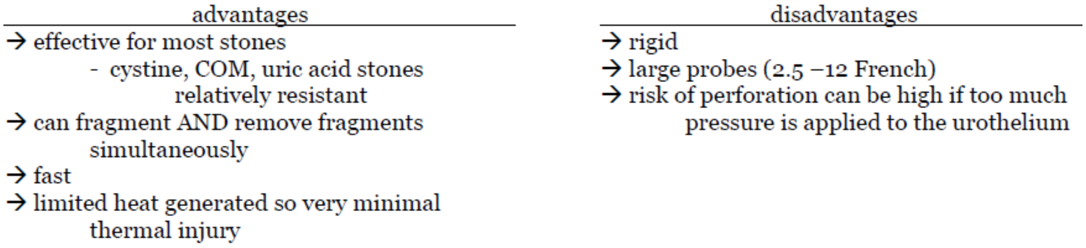


advantages	disadvantages
→ effective for most stones (90%)	→ rigid
→ fast	→ produces large fragments
→ can pin down stones against urothelium	→ high rate of stone retropulsion
→ lowest risk of ureteral perforation (<1%)	
→ no heat generated so no thermal injury	
→ cheap	

Ultrasonic lithotripsy

Mech.:

- electrical energy vibrates piezoceramic plate which resonates at a specific frequency and generates ultrasonic waves (23,000 to 25,000 Hz)
- ultrasound energy is transformed into vibrational energy via hollow steel probe (small 2.5 French solid probe)
- probe tip causes stone to resonant at high frequency and to break
- soft tissue doesn’t resonate and so isn’t damaged



advantages	disadvantages
→ effective for most stones - cystine, COM, uric acid stones relatively resistant	→ rigid
→ can fragment AND remove fragments simultaneously	→ large probes (2.5 –12 French)
→ fast	→ risk of perforation can be high if too much pressure is applied to the urothelium
→ limited heat generated so very minimal thermal injury	

Endourology techniques

Percutaneous nephrolithotomy (PNL)

- Since the 1980s PNL has been developed as the standard procedure for large renal calculi.
- Different rigid and flexible endoscopes are available and the selection is mainly based on the surgeon's own preference.
- Standard access tracts are 24-30 F.
- So called **"Mini-PNL"** was introduced initially for paediatric use, but has also become popular in adults.
    - Usually, the term Mini-PNL is used for access sheaths < 18 F, however, the terminology has not been standardised.

Intracorporeal lithotripsy

- Several methods for intracorporal lithotripsy are available
- With rigid nephroscopy
    - **ultrasonic** and **pneumatic** systems most commonly used.
- Flexible endoscopes
    - **laser lithotripsy** to maintain tip deflection and the Ho:YAG laser has become the standard, as for ureteroscopy.
- **Electrohydraulic lithotripsy (EHL)** is highly effective but is no longer considered as a first-line technique, due to frequent collateral damage.

GR	Recommendations
A*	Ultrasonic, ballistic and Ho:YAG devices are recommended for intracorporeal lithotripsy during PNL.
	When using flexible instruments, the Ho:YAG laser is currently the most effective device.

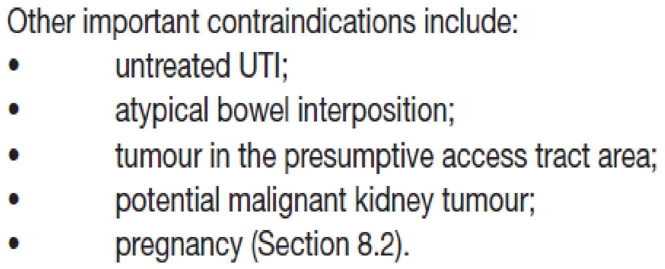
Extraction tools

- Stones or stone fragments are extracted from the kidney through the access sheath of the nephroscope using **forceps or baskets**.
- Nitinol (nickel-titanium alloy) baskets provide additional advantages compared with steel wire baskets, as increased flexibility.
- Tipless versions of nitinol baskets are available for use in calices.

Best clinical practice

Contraindications

- All contraindications for general anaesthesia apply.
- Patients receiving anticoagulant therapy must be monitored carefully pre- and postoperatively. Anticoagulant therapy must be discontinued before PNL.

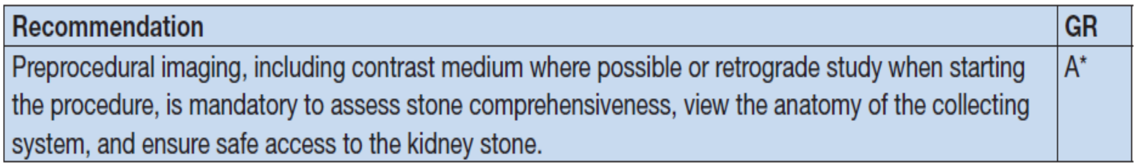


Other important contraindications include:

- untreated UTI;
- atypical bowel interposition;
- tumour in the presumptive access tract area;
- potential malignant kidney tumour;
- pregnancy (Section 8.2).

Preoperative imaging Preprocedural evaluations are summarised in Chapter 3.

- In particular for PNL, US or CT of the kidney and the surrounding structures can provide information about interpositioned organs within the planned percutaneous path (e.g., spleen, liver, large bowel, pleura, and lung).



Recommendation	GR
Preprocedural imaging, including contrast medium where possible or retrograde study when starting the procedure, is mandatory to assess stone comprehensiveness, view the anatomy of the collecting system, and ensure safe access to the kidney stone.	A*

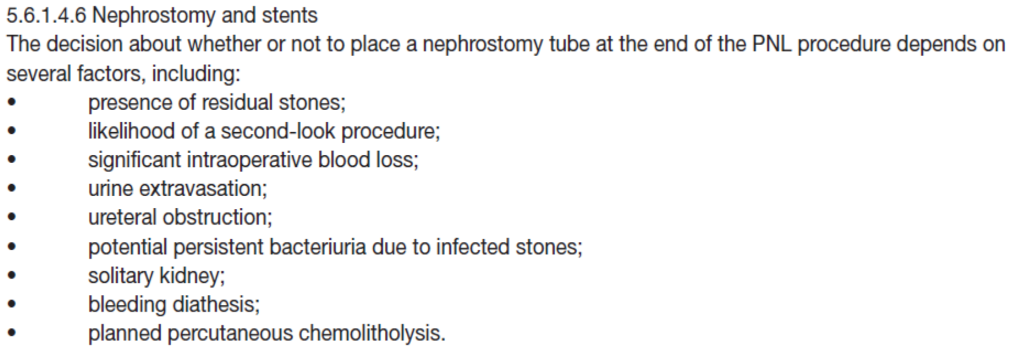
- Although the supine position confers some advantages, it depends on appropriate equipment being available to position the patient correctly, for example, X-ray devices and operating table.

Puncture Colon interposition in the access tract of PNL can lead to **colon injuries**. Although rare, such injuries are more on the left kidney.

- Preoperative CT or intraoperative US allows identification of the tissue between the skin and kidney and lowers the incidence of bowel injury.

Dilatation

- Dilatation of the percutaneous access tract can be achieved using a metallic telescope, single (serial) dilators, or a balloon dilatator. The difference in outcomes is less related to the technology used than to the experience of the surgeon.



5.6.1.4.6 Nephrostomy and stents

The decision about whether or not to place a nephrostomy tube at the end of the PNL procedure depends on several factors, including:

- presence of residual stones;
- likelihood of a second-look procedure;
- significant intraoperative blood loss;
- urine extravasation;
- ureteral obstruction;
- potential persistent bacteriuria due to infected stones;
- solitary kidney;
- bleeding diathesis;
- planned percutaneous chemolitholysis.

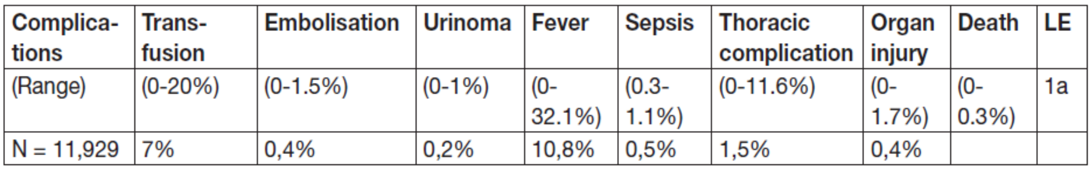
- **Tubeless PNL** is performed without a nephrostomy tube. When neither a nephrostomy tube nor a ureteral stent is introduced, the procedure is known as **totally tubeless PNL**.
- In uncomplicated cases, the latter procedure results in a shorter hospital stay, with no disadvantages reported.

GR	**LE**	**Recommendation**
A	1b	In uncomplicated cases, tubeless (without nephrostomy tube) or totally tubeless (without nephrostomy tube and ureteral stent) PNL procedures provide a safe alternative.

Management of complications

- The most common postoperative complications associated with PNL are:
    - fever and bleeding, urinary leakage, and problems due to residual stones.
- review on complications following PNL using validated **Dindo-modified Clavien System** and showed a normal (uncomplicated) postoperative course in 75% of patients (Clavien 0)

Table 13: Complications following PNL

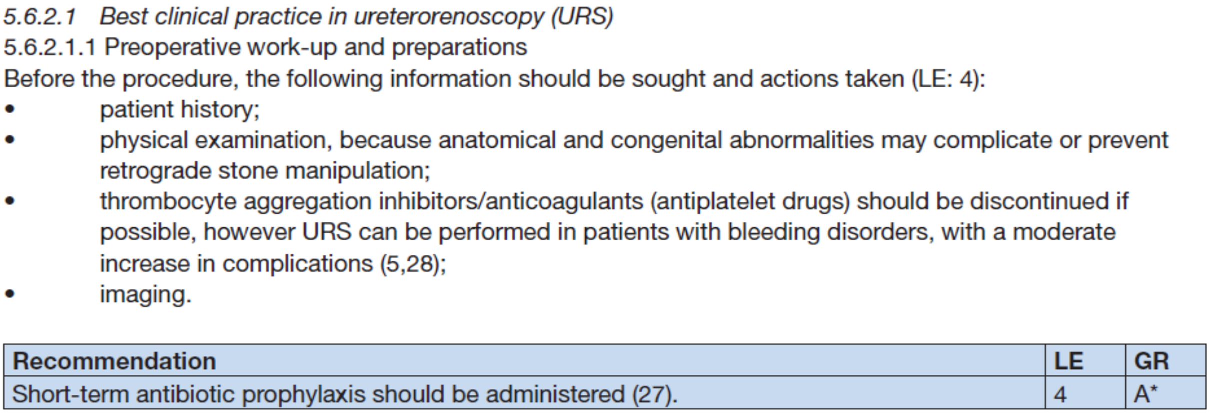


Complica-tions	Trans-fusion	Embolisation	Urinoma	Fever	Sepsis	Thoracic complication	Organ injury	Death	LE
(Range)	(0-20%)	(0-1.5%)	(0-1%)	(0-32.1%)	(0.3-1.1%)	(0-11.6%)	(0-1.7%)	(0-0.3%)	1a
N = 11,929	7%	0,4%	0,2%	10,8%	0,5%	1,5%	0,4%		

- **Urinary leakage and stone clearance** can be viewed endoscopically and by X-ray anlaysis. In doubtful cases, complications can be minimised by performing standard rather than totally tubeless PNL.
- **Perioperative fever** can occur, even with a sterile preoperative urinary culture and perioperative antibiotic prophylaxis, because the kidney stones themselves may be a source of infection.
    - Intraoperative kidney stone culture may therefore help to select postoperative antibiotics.
    - Intraoperative irrigation pressure < 30 mm Hg and unobstructed postoperative urinary drainage may be important factors in preventing postoperative sepsis.
    - Well-positioned or specially designed access sheaths can prevent high intrapelvic irrigation pressure.
- **Bleeding** after PNL may be treated by brief clamping of the nephrostomy tube. Super-selective embolic occlusion of the artery may become necessary in case of severe bleeding.

Ureterorenoscopy (URS) (including retrograde access to renal collecting system)

- URS has dramatically changed the management of ureteral calculi.
- The current standard for rigid ureterorenoscopes are tip diameters of < 8 F. Rigid URS can be used for the whole ureter.
- Major technological progress has been achieved for retrograde intrarenal surgery [**RIRS** (flexible URS)], with improved deflection mechanisms, better durability, and recently, digital optical systems.
- Initial experience with digital scopes has demonstrated shorter operation times due to the improvement in image quality.
- In Europe, RIRS is mainly used for the renal collecting system and - in cases with difficult anatomy - the upper ureter.



5.6.2.1 Best clinical practice in ureterorenoscopy (URS)

5.6.2.1.1 Preoperative work-up and preparations

Before the procedure, the following information should be sought and actions taken (LE: 4):

- patient history;
- physical examination, because anatomical and congenital abnormalities may complicate or prevent retrograde stone manipulation;
- thrombocyte aggregation inhibitors/anticoagulants (antiplatelet drugs) should be discontinued if possible, however URS can be performed in patients with bleeding disorders, with a moderate increase in complications (5,28);
- imaging.

Recommendation	LE	GR
Short-term antibiotic prophylaxis should be administered (27).	4	A*

Contraindications

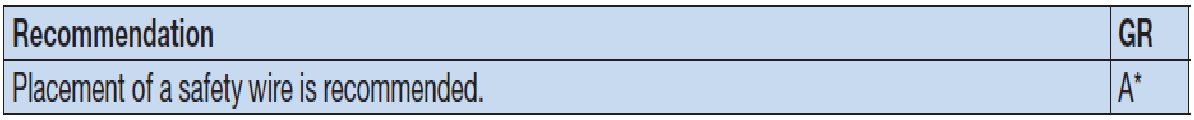
- Apart from general problems, for example, with general anaesthesia or untreated UTIs, URS can be performed in all patients without any specific contraindications.
- Specific problems such as ureteral strictures may prevent successful retrograde stone management.

Access to the upper urinary tract Most interventions are performed under general anaesthesia, although local or spinal anaesthesia is possible.

- Instrument miniaturisation means that intravenous sedation can be used to achieve the same outcome.
    - Intravenous sedation with miniaturised instruments is especially suitable for female patients with distal ureteral stones.
    - However, kidney movement is more pronounced with local or intravenous anaesthesia, which may hinder RIRS.
- **Antegrade URS** is an option for large, impacted proximal ureteral calculi.

Safety aspects Fluoroscopic equipment must be available in the operating room.

- We recommend placement of a safety wire. A safety wire prevents false passage in case of perforation, and ensures that a JJ stent can be inserted in difficult situations, thus avoiding more significant complications.
- Retrograde access to the upper urinary tract is usually obtained under endoscopic guidance.
- Balloon and plastic dilators are available if necessary. If insertion of a flexible URS is difficult, prior rigid ureteroscopy can be helpful for optical dilatation. If ureteral access is not possible, insertion of a JJ stent followed by URS after 7-14 days offers an alternative procedure.



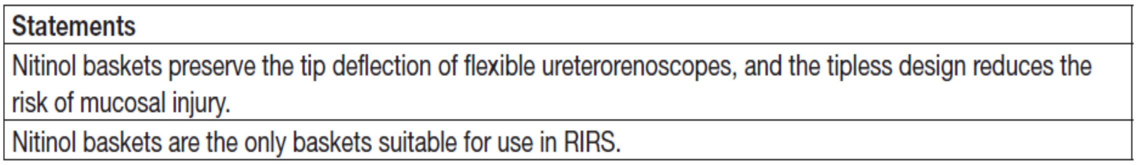
Recommendation	GR
Placement of a safety wire is recommended.	A*

Ureteral access sheaths

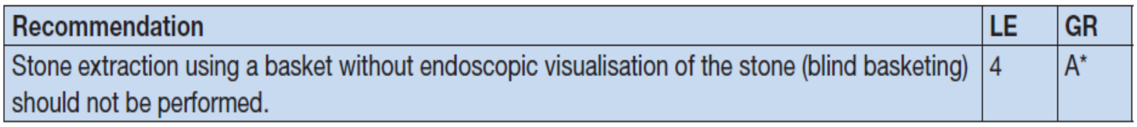
- ***Hydrophilic-coated ureteral access sheaths***, which are available in different calibres (inner diameter from 9 F upwards), can be inserted via a guide wire, with the tip placed in the proximal ureter.
    - Adv.
        - easy multiple access to the upper urinary tract
        - improves vision by establishing a continuous outflow,
        - decreasing intrarenal pressure, and
        - potentially reducing operating time.
- The insertion of ureteral access sheaths may lead to ureteral damage

Stone extraction

- The aim of URS is complete stone removal (especially ureteric stones). *"**Smash and go**"* strategies should be limited to the treatment of large renal stones.
- Stones can be extracted by endoscopic forceps or baskets. Forceps allow safe release of stone fragments if they become stuck within the ureter, but extraction takes longer than when using baskets.
- Only baskets made of nitinol can be used for RIRS.



Statements
Nitinol baskets preserve the tip deflection of flexible ureterorenoscopes, and the tipless design reduces the risk of mucosal injury.
Nitinol baskets are the only baskets suitable for use in RIRS.

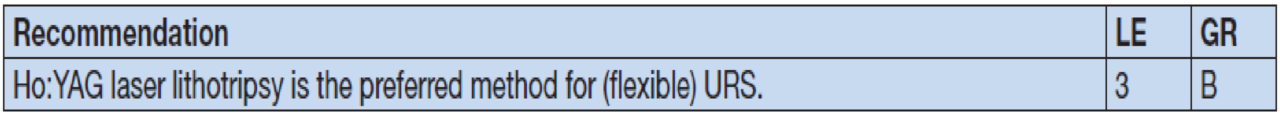


Recommendation	LE	GR
Stone extraction using a basket without endoscopic visualisation of the stone (blind basketing) should not be performed.	4	A*

- Stones that cannot be extracted directly must be disintegrated. If it is difficult to access stones that need disintegration within the lower renal pole, it may help to displace them into a more accessible calyx.

Intracorporeal lithotripsy

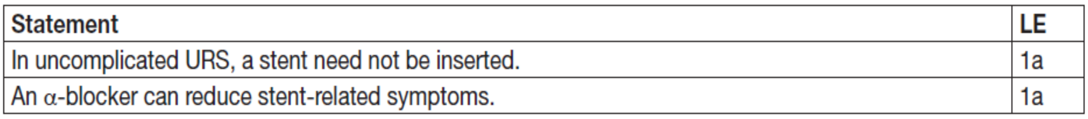
- The most effective lithotripsy system is the **Ho:YAG laser**, which has become the gold standard for ureteroscopy and flexible nephroscopy because it is effective for all stone types.
- **Pneumatic** and **US systems** can be used with high disintegration efficacy in rigid URS. However, stone migration into the kidney is a common problem, which can be prevented by placement of special tools proximal of the stone.



Recommendation	LE	GR
Ho:YAG laser lithotripsy is the preferred method for (flexible) URS.	3	B

Stenting before and after URS

- Routine stenting is no longer necessary before URS. However, pre-stenting facilitates ureteroscopic management of stones, improves the SFR, and reduces complications.
- Most urologists routinely insert a JJ stent following URS but routine stenting after uncomplicated URS (complete stone removal) is not necessary (stenting might be associated with higher postoperative morbidity). A ureteric catheter with a shorter indwelling time (1 day) may be used as well, with similar results.
- Stents should be inserted in patients who are
  - At increased risk of complications (e.g., residual fragments, bleeding, perforation, UTIs, or pregnancy), and
  - in all doubtful cases, to avoid stressful emergencies.
- The ideal duration of stenting is not known. Most urologists favour 1-2 weeks after URS. Patients should be followed up with a plain abdominal film (KUB), CT or US.
- α-Blockers reduce morbidity of ureteral stents,increase tolerability.



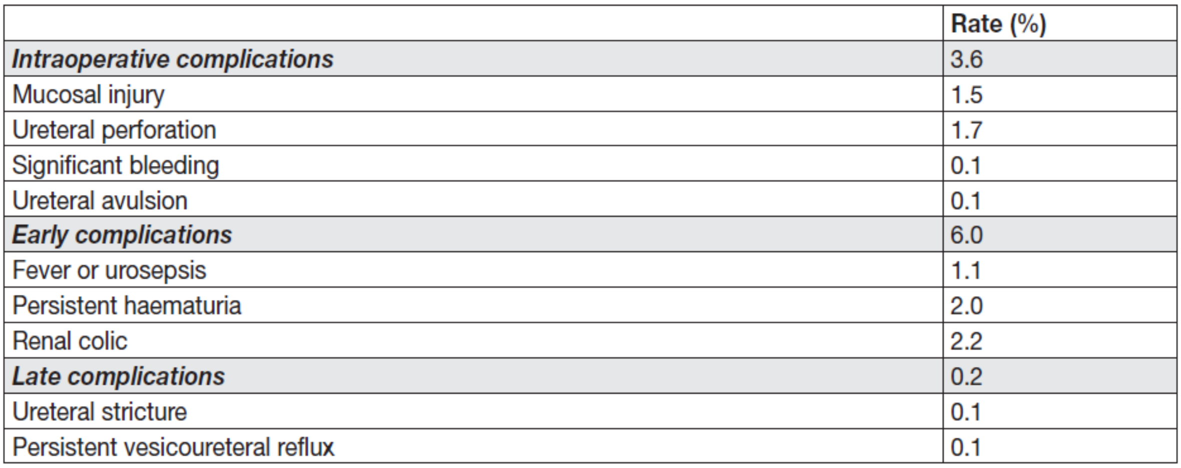
Statement	LE
In uncomplicated URS, a stent need not be inserted.	1a
An α-blocker can reduce stent-related symptoms.	1a

Complications

The overall complication rate after URS is 10-25% (Table 14). Most are minor and do not require intervention.

Ureteral avulsion and strictures used to be greatly feared, but nowadays are rare in experienced hands (< 1%). Previous **perforations** are the most important risk factor for complications.

Table 14: Complications of URS*



	Rate (%)
Intraoperative complications	3.6
Mucosal injury	1.5
Ureteral perforation	1.7
Significant bleeding	0.1
Ureteral avulsion	0.1
Early complications	6.0
Fever or urosepsis	1.1
Persistent haematuria	2.0
Renal colic	2.2
Late complications	0.2
Ureteral stricture	0.1
Persistent vesicoureteral reflux	0.1

Open and laparoscopic surgery for removal of renal stones

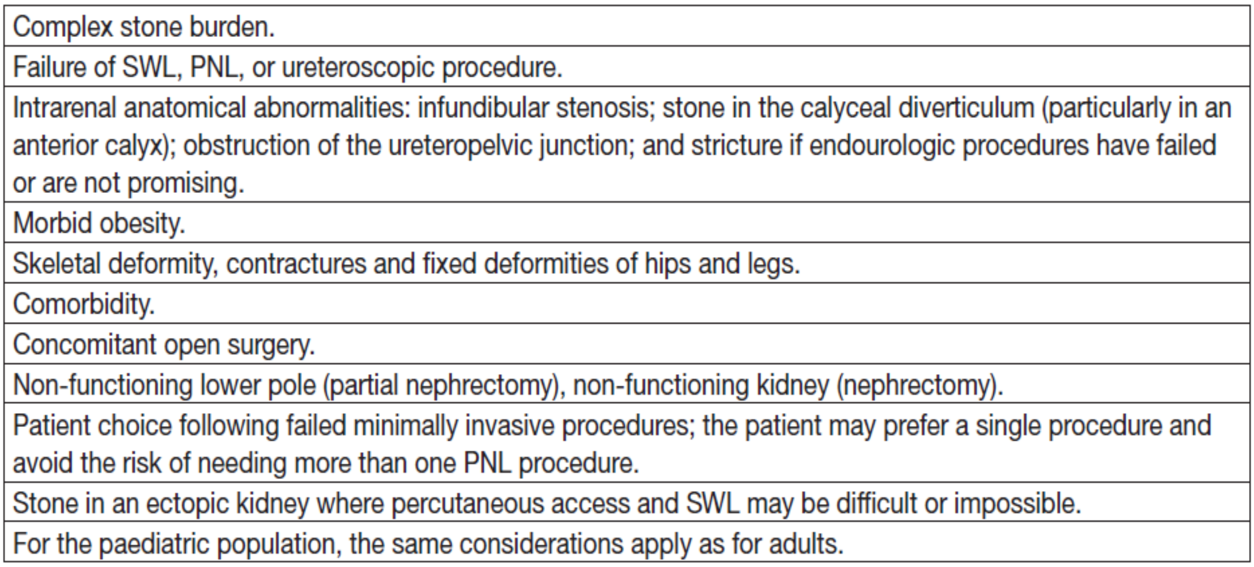
Open surgery

- Advances in SWL and endourological surgery (URS and PNL) have significantly decreased the indications for open stone surgery, which is now often a second- or third-line treatment option needed in only 1-5% of cases.
- The incidence of open stone surgery is ~1.5% of all stone removal interventions in developed countries, and in developing countries, it has dropped from 25% to 3.5% in recent years.
- However, open surgery is still needed for the most difficult stones, which supports the importance of maintaining proficiency, skills and expertise in open renal and ureteral surgical techniques such as **extended pyelolithotomy, pyelonephrolithotomy, anatrophic nephrolithotomy, multiple radial nephrotomy, partial nephrectomy,** and **renal surgery under hypothermia**
- Recently, *intraoperative B-mode scanning and Doppler sonography* have been used to identify avascular areas in the renal parenchyma that are close to the stone or dilated calices.
  - This allows removal of large staghorn stones by multiple small radial nephrotomy, without loss of kidney function.

Indications for open surgery

- There is a consensus that most complex stones, including partial and complete staghorn stones, should be approached primarily with PNL or combined PNL and SWL.
- If a reasonable number of percutaneous approaches are not likely to be successful, or if multiple, endourological approaches have been performed unsuccessfully, open surgery may be a valid treatment option.

Table 15: Indications for open surgery



Complex stone burden.
Failure of SWL, PNL, or ureteroscopic procedure.
Intrarenal anatomical abnormalities: infundibular stenosis; stone in the calyceal diverticulum (particularly in an anterior calyx); obstruction of the ureteropelvic junction; and stricture if endourologic procedures have failed or are not promising.
Morbid obesity.
Skeletal deformity, contractures and fixed deformities of hips and legs.
Comorbidity.
Concomitant open surgery.
Non-functioning lower pole (partial nephrectomy), non-functioning kidney (nephrectomy).
Patient choice following failed minimally invasive procedures; the patient may prefer a single procedure and avoid the risk of needing more than one PNL procedure.
Stone in an ectopic kidney where percutaneous access and SWL may be difficult or impossible.
For the paediatric population, the same considerations apply as for adults.

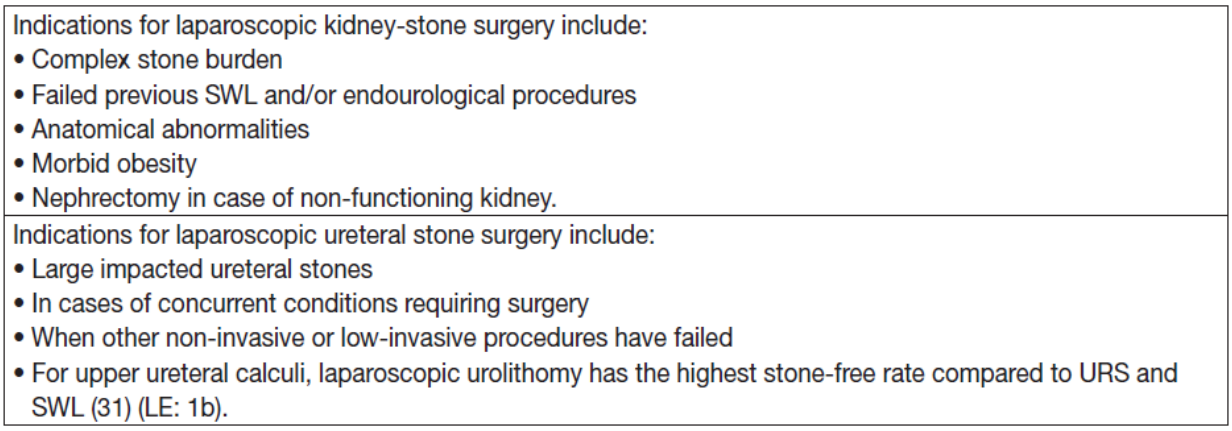
Laparoscopic surgery

- Laparoscopic urological surgery is increasingly replacing open surgery.
- Today laparoscopic surgery is used to remove renal and ureteric stones in certain situations, including
    - complex stone burden,
    - failed previous SWL and/or endourological procedures,
    - anatomical abnormalities or morbid obesity,
    - and planned nephrectomy of a stone-containing non-functioning kidney.
- Although surgical pyelolithotomy is rarely indicated, laparoscopic removal of *solitary large renal pelvic* as well as *anterior calyceal diverticular stones* is possible in selected cases.
- Stone-free rates are reported to be equal to PNL, but complications are more frequent, using laparoscopic retroperitoneal pyelolithotomy.
- Additionally, as a less-invasive option, *laparoscopic anatrophic nephrolithotomy* has been found to be effective for the removal of

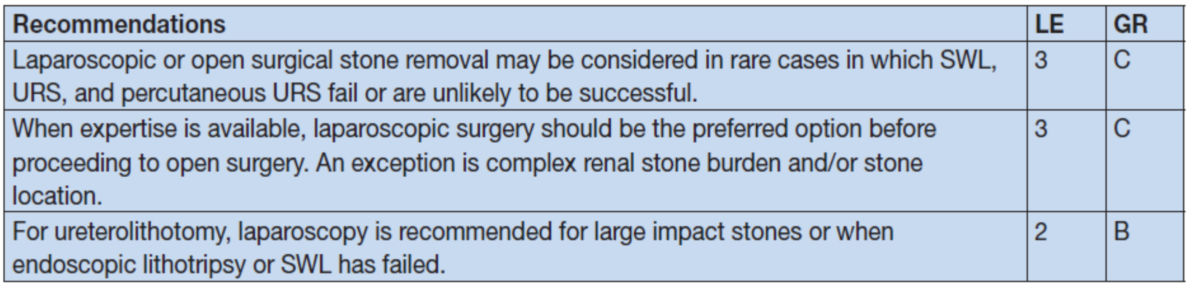
complex staghorn stones; (PNL is still the method of choice and laparoscopic stone removal should be reserved for selected cases).

- Laparoscopic ureterolithotomy is relatively easy, with SFRs up to 100% provided expertise is available.
    - It can replace open surgery in most situations.
    - Retroperitoneal and transperitoneal laparoscopic access to all portions of the ureter has been reported, although laparoscopic ureterolithotomy in the distal ureter is less successful than in the middle and proximal ureter, but the size of the stone does not appear to influence outcome.
    - Although highly effective, laparoscopic ureterolithotomy is not first-line therapy in most cases because of its invasiveness, longer recovery time, and greater risk of associated complications compared to SWL and URS.

Table 16: Indications for laparoscopic stone surgery



Indications for laparoscopic kidney-stone surgery include: • Complex stone burden • Failed previous SWL and/or endourological procedures • Anatomical abnormalities • Morbid obesity • Nephrectomy in case of non-functioning kidney.
Indications for laparoscopic ureteral stone surgery include: • Large impacted ureteral stones • In cases of concurrent conditions requiring surgery • When other non-invasive or low-invasive procedures have failed • For upper ureteral calculi, laparoscopic urolithomy has the highest stone-free rate compared to URS and SWL (31) (LE: 1b).



Recommendations	**LE**	**GR**
Laparoscopic or open surgical stone removal may be considered in rare cases in which SWL, URS, and percutaneous URS fail or are unlikely to be successful.	3	C
When expertise is available, laparoscopic surgery should be the preferred option before proceeding to open surgery. An exception is complex renal stone burden and/or stone location.	3	C
For ureterolithotomy, laparoscopy is recommended for large impact stones or when endoscopic lithotripsy or SWL has failed.	2	B

INDICATION FOR ACTIVE STONE REMOVAL AND SELECTION OF PROCEDURE

Although kidney stones might be asymptomatic, ureteral stones cause acute renal colic in most cases. Treatment decisions for upper urinary tract calculi are based on several general aspects such as stone composition, stone size, and symptoms.

6.1 Indications for active removal of ureteral stones (1-3)

- Stones with low likelihood of spontaneous passage.
- Persistent pain despite adequate analgesic medication.
- Persistent obstruction.
- Renal insufficiency (renal failure, bilateral obstruction, or single kidney).

6.2 Indications for active removal of kidney stones (4)

- Stone growth.
- Stones in high-risk patients for stone formation.
- Obstruction caused by stones.
- Infection.
- Symptomatic stones (e.G., Pain or haematuria).
- Stones > 15 mm.
- Stones < 15 mm if observation is not the option of choice.
- Patient preference.
- Comorbidity.
- Social situation of the patient (e.G., Profession or travelling).
- Choice of treatment.

Natural history of caliceal stones

Natural history of small, non-obstructing asymptomatic lower pole calculi is not well defined, and the risk of progression is unclear. There is still no consensus on the follow-up duration, and timing and type of intervention.

Statement	**LE**
Although the question of whether caliceal stones should be treated is still unanswered, stone growth, de novo obstruction, associated infection, and acute and/or chronic pain are indications for treatment (4-6).	3

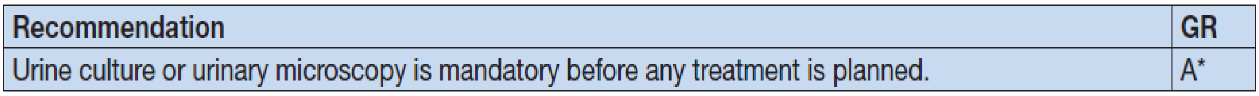
- Excellent SFRs and pain relief have been reported after removal of small caliceal stones by SWL, PNL or URS, which indicates the need for removal of symptomatic caliceal stones.

GR	**Recommendations**
C	For asymptomatic caliceal stones in general, active surveillance with annual follow-up of symptoms and stone status (KUB radiography, US, or NCCT) is an option for 2-3 years, whereas intervention should be considered after this period provided patients are adequately informed.
	Observation might be associated with a greater risk of necessitating more invasive procedures.

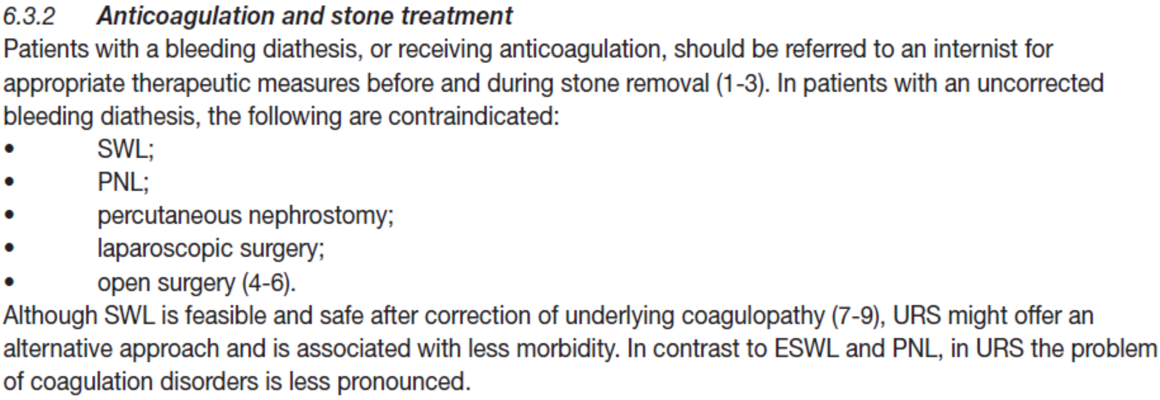
General recommendations and precautions for stone removal

Infections

- Urinary tract infections should always be treated if stone removal is planned.
- In patients with clinically significant infection and obstruction, drainage should be performed for several days, via a stent or percutaneous nephrostomy, before starting stone removal.



Recommendation	GR
Urine culture or urinary microscopy is mandatory before any treatment is planned.	A*

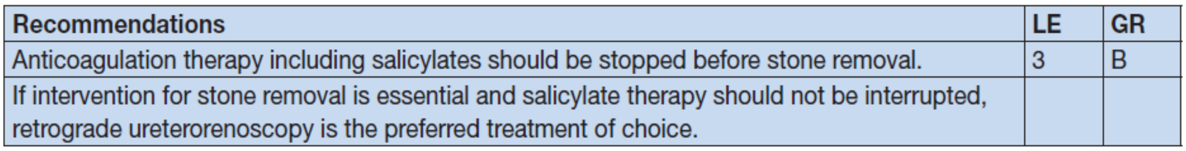


6.3.2 *Anticoagulation and stone treatment*

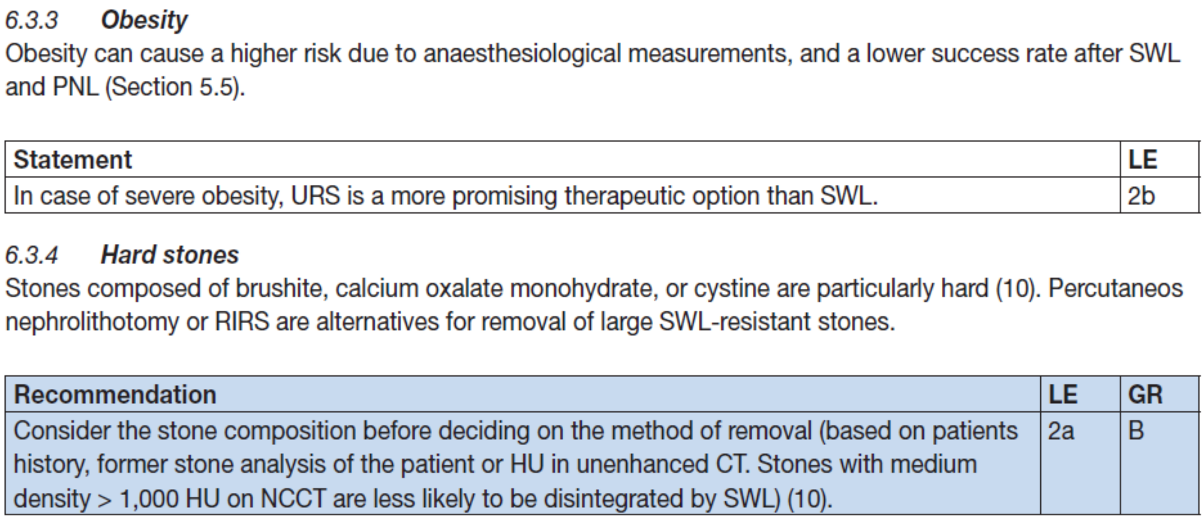
Patients with a bleeding diathesis, or receiving anticoagulation, should be referred to an internist for appropriate therapeutic measures before and during stone removal (1-3). In patients with an uncorrected bleeding diathesis, the following are contraindicated:

- SWL;
- PNL;
- percutaneous nephrostomy;
- laparoscopic surgery;
- open surgery (4-6).

Although SWL is feasible and safe after correction of underlying coagulopathy (7-9), URS might offer an alternative approach and is associated with less morbidity. In contrast to ESWL and PNL, in URS the problem of coagulation disorders is less pronounced.



Recommendations	LE	GR
Anticoagulation therapy including salicylates should be stopped before stone removal.	3	B
If intervention for stone removal is essential and salicylate therapy should not be interrupted, retrograde ureterorenoscopy is the preferred treatment of choice.		



6.3.3 *Obesity*

Obesity can cause a higher risk due to anaesthesiological measurements, and a lower success rate after SWL and PNL (Section 5.5).

Statement	LE
In case of severe obesity, URS is a more promising therapeutic option than SWL.	2b

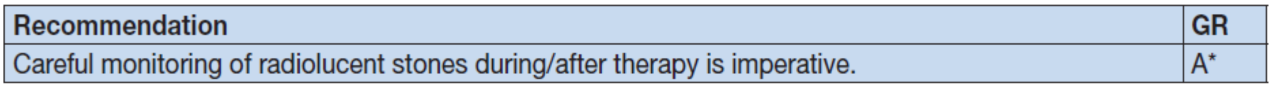
6.3.4 *Hard stones*

Stones composed of brushite, calcium oxalate monohydrate, or cystine are particularly hard (10). Percutaneos nephrolithotomy or RIRS are alternatives for removal of large SWL-resistant stones.

Recommendation	LE	GR
Consider the stone composition before deciding on the method of removal (based on patients history, former stone analysis of the patient or HU in unenhanced CT. Stones with medium density > 1,000 HU on NCCT are less likely to be disintegrated by SWL) (10).	2a	B

Radiolucent stones

- Stones composed of uric acid, but not sodium or ammonium urate, can be dissolved by **oral chemolysis**. Differentiation is done by urinary pH measurement
- **Postoperative monitoring of radiolucent stones during therapy is the domain of US** (however repeat NCCT might be necessary).



Recommendation	GR
Careful monitoring of radiolucent stones during/after therapy is imperative.	A*

Steinstrasse

- Def.
    - an accumulation of stone fragments or stone gravel in the ureter, which does not pass within a reasonable period of time, and interferes with the passage of urine.
- Steinstrasse occurs in 4-7% cases of SWL, and the major factor in steinstrasse formation is **stone size**.
- Insertion of a ureteral stent before SWL prevents formation of steinstrasse only in stones > 15 mm in diameter.
- Symptoms of steinstrasse include:

  - flank pain, fever, nausea and vomiting, bladder irritation, or it may be asymptomatic.
  - A major problem of steinstrasse is ureter obstruction, which can be silent in 25% of cases and lead to kidney failure. Anuria occurs in 5% of cases of steinstrasse in treatment of solitary kidneys.
- When steinstrasse is asymptomatic, conservative treatment is an initial option, depending on patient preference to comply with close surveillance.
- **Medical expulsion therapy** significantly increases stone expulsion and reduces the need for endoscopic intervention.

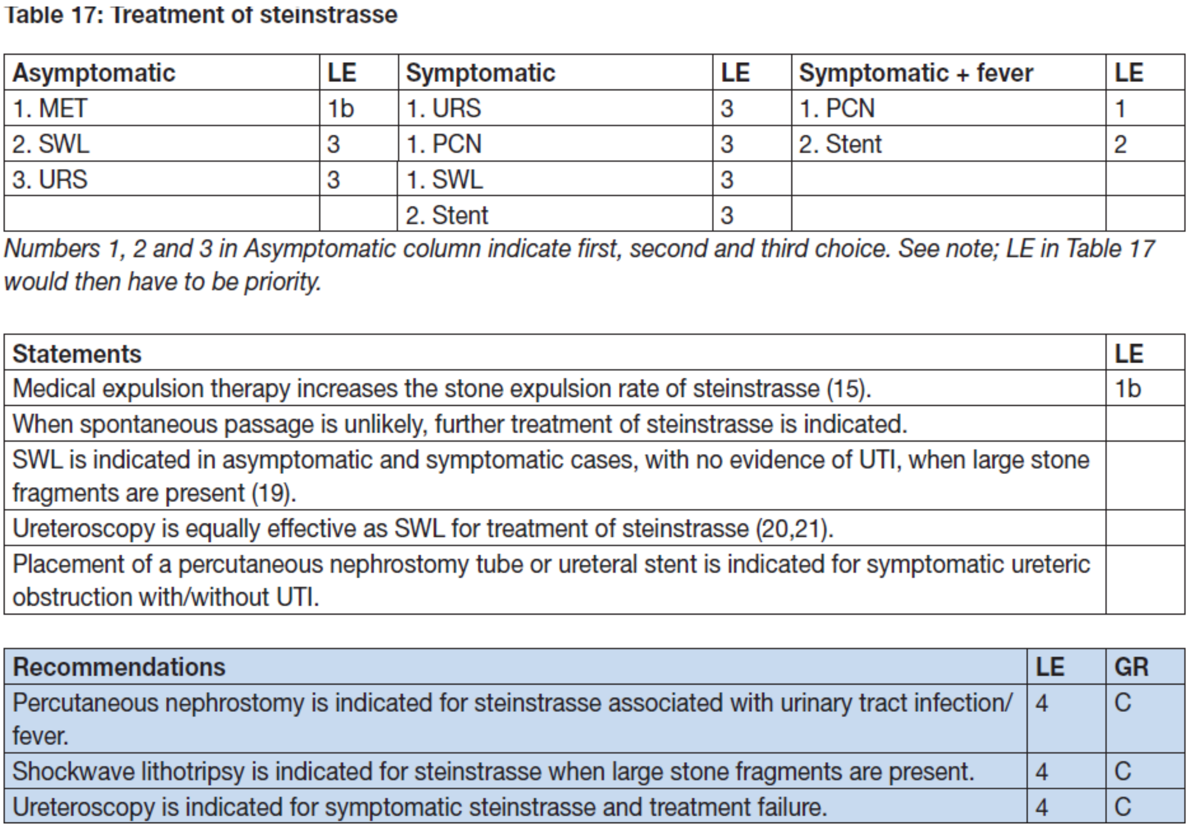


Table 17: Treatment of steinstrasse

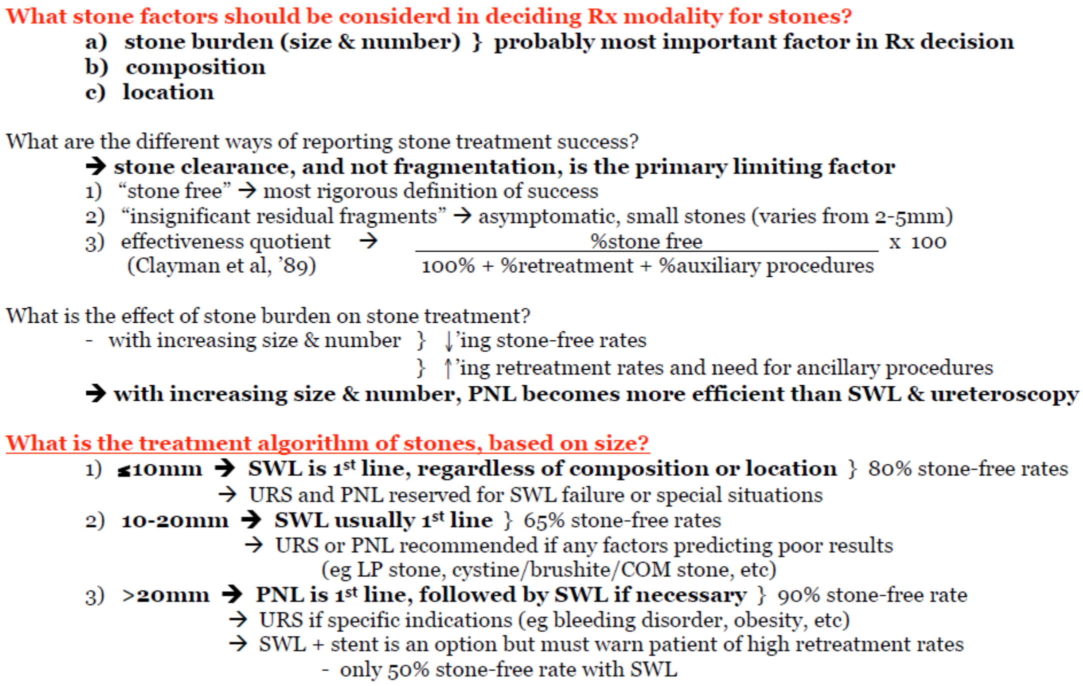
Asymptomatic	LE	Symptomatic	LE	Symptomatic + fever	LE
1. MET	1b	1. URS	3	1. PCN	1
2. SWL	3	1. PCN	3	2. Stent	2
3. URS	3	1. SWL	3		
		2. Stent	3		

Numbers 1, 2 and 3 in Asymptomatic column indicate first, second and third choice. See note; LE in Table 17 would then have to be priority.

Statements	LE
Medical expulsion therapy increases the stone expulsion rate of steinstrasse (15).	1b
When spontaneous passage is unlikely, further treatment of steinstrasse is indicated.	
SWL is indicated in asymptomatic and symptomatic cases, with no evidence of UTI, when large stone fragments are present (19).	
Ureteroscopy is equally effective as SWL for treatment of steinstrasse (20,21).	
Placement of a percutaneous nephrostomy tube or ureteral stent is indicated for symptomatic ureteric obstruction with/without UTI.	

Recommendations	LE	GR
Percutaneous nephrostomy is indicated for steinstrasse associated with urinary tract infection/ fever.	4	C
Shockwave lithotripsy is indicated for steinstrasse when large stone fragments are present.	4	C
Ureteroscopy is indicated for symptomatic steinstrasse and treatment failure.	4	C

Selection of procedure for active removal of kidney stones



What stone factors should be considerd in deciding Rx modality for stones?

- **a) stone burden (size & number) } probably most important factor in Rx decision**
- **b) composition**
- **c) location**

What are the different ways of reporting stone treatment success?

- → **stone clearance, and not fragmentation, is the primary limiting factor**
- 1) "stone free" → most rigorous definition of success
- 2) "insignificant residual fragments" → asymptomatic, small stones (varies from 2-5mm)
- 3) effectiveness quotient (Clayman et al, '89) → $\frac{\%\text{stone free}}{100\% + \%\text{retreatment} + \%\text{auxiliary procedures}} \times 100$

What is the effect of stone burden on stone treatment?

- with increasing size & number } ↓'ing stone-free rates
  } ↑'ing retreatment rates and need for ancillary procedures

→ **with increasing size & number, PNL becomes more efficient than SWL & ureteroscopy**

What is the treatment algorithm of stones, based on size?

1) **≤10mm → SWL is 1st line, regardless of composition or location** } 80% stone-free rates
   → URS and PNL reserved for SWL failure or special situations
2) **10-20mm → SWL usually 1st line** } 65% stone-free rates
   → URS or PNL recommended if any factors predicting poor results
   (eg LP stone, cystine/brushite/COM stone, etc)
3) **>20mm → PNL is 1st line, followed by SWL if necessary** } 90% stone-free rate
   → URS if specific indications (eg bleeding disorder, obesity, etc)
   → SWL + stent is an option but must warn patient of high retreatment rates
   - only 50% stone-free rate with SWL

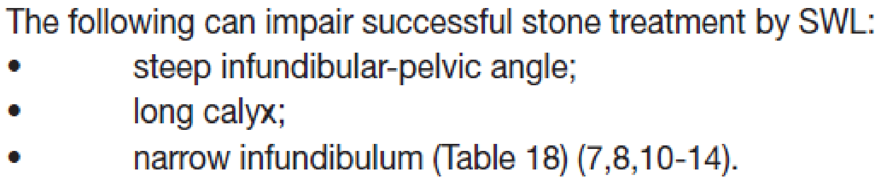
Stones in renal pelvis or upper/middle calices

Shockwave lithotripsy, PNL and RIRS are available treatment modalities for renal calculi.

- PNL efficacy is not affected by stone size, the SFRs after SWL or URS are inversely proportional to stone size.
- Shockwave lithotripsy achieves excellent SFRs for stones up to 20 mm, except for those at the lower pole.
  - Therefore, SWL remains the first method of choice for such stones.
- Larger stones > 20 mm should be treated primarily by PNL, because SWL often requires multiple treatments, and has the risk of ureteral obstruction (colic or steinstrasse) with the need for adjunctive procedures.
- Retrograde renal surgery cannot be recommended as first-line treatment for stones > 20 mm, for which SFR is decreasing, and staged procedures have become necessary.

Stones in the lower renal pole

- The stone clearance rate after SWL seems to be lower for stones in the inferior calyx than for other intrarenal locations.
    - Although the disintegration efficacy of SWL is not limited compared to other locations, the fragments often remain in the calyx and cause recurrent stone formation.
    - The reported SFR of SWL for lower pole calculi is 25-85%.
- The preferential use of endoscopic procedures is under discussion.



The following can impair successful stone treatment by SWL:

- steep infundibular-pelvic angle;
- long calyx;
- narrow infundibulum (Table 18) (7,8,10-14).

- The value of supportive measures such as inversion, vibration or hydration remains under discussion.

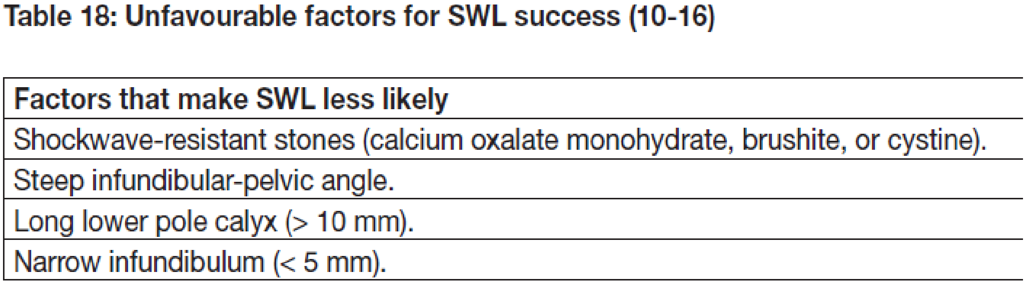


Table 18: Unfavourable factors for SWL success (10-16)

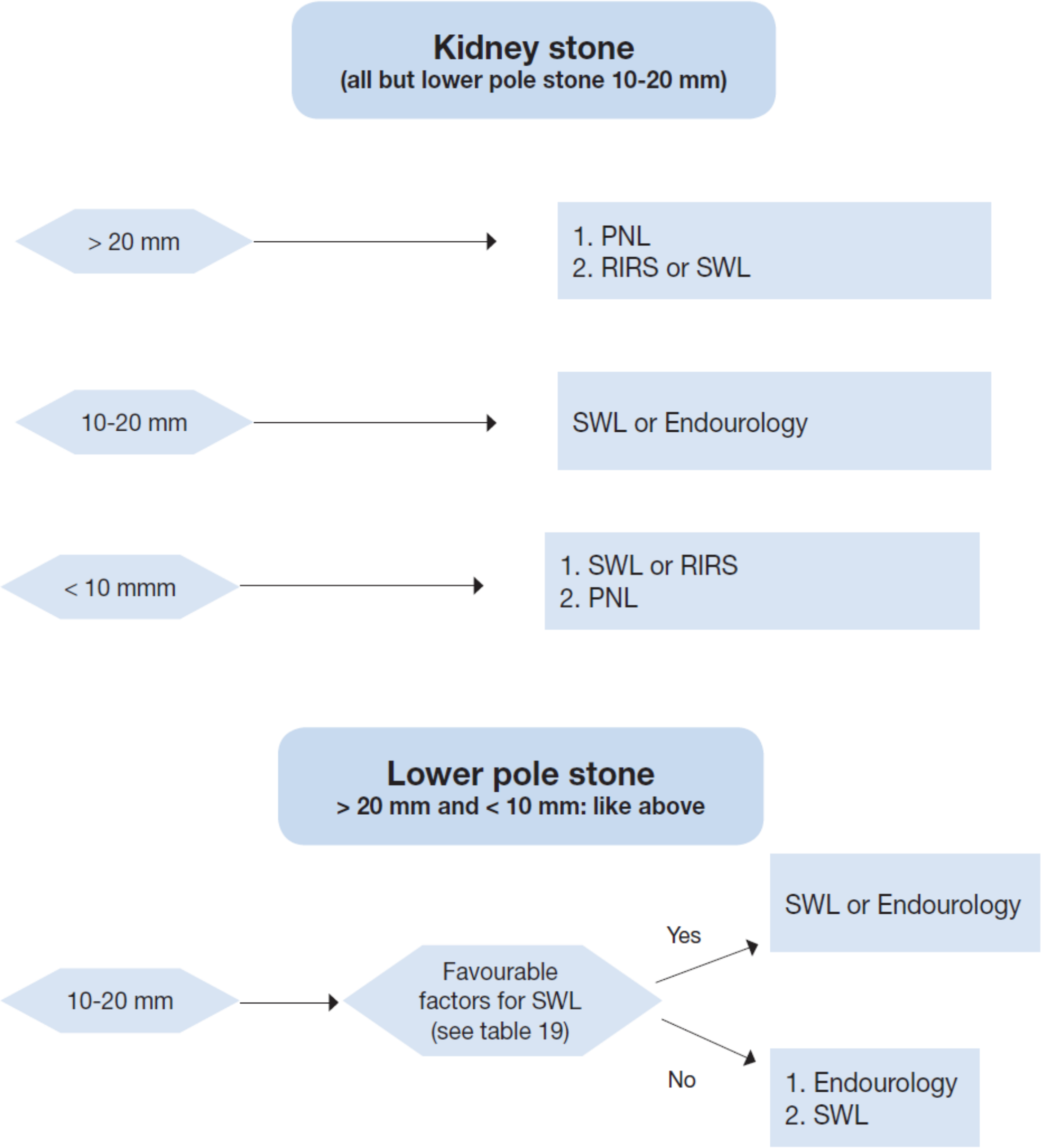
Factors that make SWL less likely
Shockwave-resistant stones (calcium oxalate monohydrate, brushite, or cystine).
Steep infundibular-pelvic angle.
Long lower pole calyx (> 10 mm).
Narrow infundibulum (< 5 mm).

- Shockwave lithotripsy for the lower pole is often disappointing, therefore, **endourological procedures (PNL and RIRS) are recommended for stones > 15 mm** even smaller if ESWL is not recommended.
- Retrograde renal surgery seems to have comparable efficacy to SWL (last-generation ureterorenoscopes suggested an advantage of URS over SWL, but at the expense of greater invasiveness).
- Depending on operator skills, stones up to 3 cm can be treated efficiently by RIRS.
- In complex stone cases, a combined antegrade and retrograde approach may be indicated. However, staged procedures are frequently required.

Recommendations	GR
SWL remains the method of first choice for stones < 2 cm within the renal pelvis and upper or middle calices. Larger stones should be treated by PNL.	B*
Flexible URS cannot be recommended as first-line treatment, especially for stones > 1.5 cm in the renal pelvis and upper or middle calices, for which SFR after RIRS is decreasing, and staged procedures become necessary.	B*
For the lower pole, PNL or RIRS is recommended, even for stones > 1.5 cm, because the efficacy of SWL is limited (depending on favourable and unfavourable factors for SWL).	B*

**Upgraded following panel consensus*
SWL = shockwave lithotripsy; PNL = percutaneous nephrolithotomy; URS = ureterorenoscopy; SFR = stone free rate; RIRS = retrograde renal surgery

Figure 1: Treatment algorithm for renal calculi



In complex stone cases, open or laparocopic approaches are possible alternatives (see appropriate chapters).

Selection of procedure for active removal of ureteral stones

Methodology

- Stone free rates were analysed for SWL and URS.

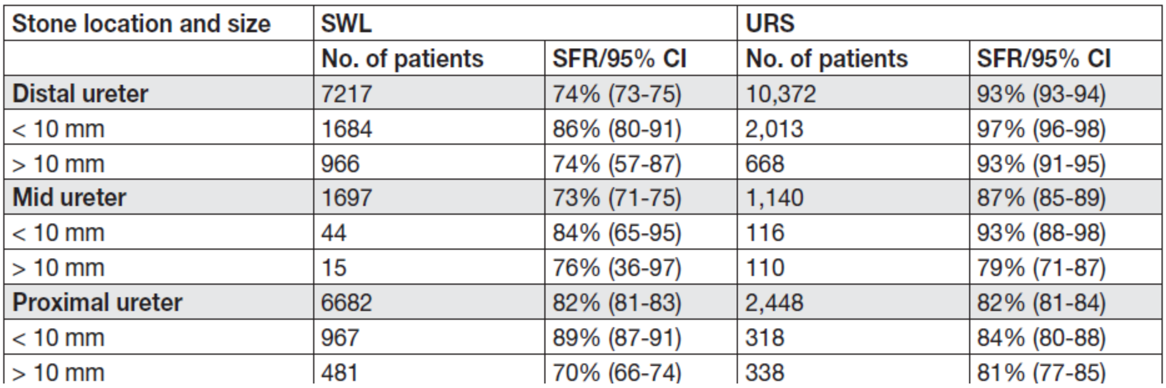
Extracorporeal shock wave lithotripsy and ureteroscopy

- For proximal stones,
  - No difference in overall SFRs between SWL and URS was detected.
  - for stone size, in proximal ureteral stones < 10 mm, SWL had a higher SFR than URS had.
  - For stones > 10 mm, URS had superior SFRs.
  - This can be attributed to the fact that proximal ureteral stones treated with URS did not vary significantly with size, whereas the SFR following SWL negatively correlated with stone size.

- For all mid-ureteral stones,
  - URS appears superior to SWL,
- For all distal stones,
  - URS better SFRs overall, compared to other methods for active stone removal, independent of stone size.

6.5.2.1 ***Stone free rates (SFRs)***

- **SFRs after primary treatment with SWL and URS in the overall population**



Stone location and size	SWL		URS	
	No. of patients	SFR/95% CI	No. of patients	SFR/95% CI
Distal ureter	7217	74% (73-75)	10,372	93% (93-94)
< 10 mm	1684	86% (80-91)	2,013	97% (96-98)
> 10 mm	966	74% (57-87)	668	93% (91-95)
Mid ureter	1697	73% (71-75)	1,140	87% (85-89)
< 10 mm	44	84% (65-95)	116	93% (88-98)
> 10 mm	15	76% (36-97)	110	79% (71-87)
Proximal ureter	6682	82% (81-83)	2,448	82% (81-84)
< 10 mm	967	89% (87-91)	318	84% (80-88)
> 10 mm	481	70% (66-74)	338	81% (77-85)

- The SFRs for URS remained significantly better than those for SWL for distal ureteral stones < 10 mm and > 10 mm and for proximal ureteral stones > 10 mm. The SFRs for mid-ureteral stones did not differ significantly between URS and SWL.
- favourable SFRs have been reported using RIRS flexible (87%) or rigid or semi-rigid URS (77%)

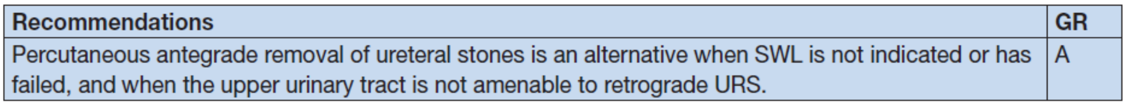
Complications

- Although URS is effective for ureteric calculi, it has greater potential for complications.
- In the current endourological era, with access to newer and smaller rigid and flexible instruments, and use of small-calibre intracorporeal lithotripsy devices, the complication rate and morbidity of ureteroscopy reduced.

Percutaneous antegrade ureteroscopy

- Percutaneous antegrade removal of ureteral stones is a consideration in selected cases (SFRs of 85-100%). For example,
    - for very large (> 15 mm diameter) impacted stones in the proximal ureter between the ureteropelvic junction and the lower border of the fourth lumbar vertebra, or
    - when the ureter is not amenable to retrograde manipulation.

- The complication rate is low, and no different than for any other percutaneous procedure.
- Percutaneous antegrade removal of ureteral stones associated with longer OR times, hospital stay & time to return to normal activities



Recommendations	**GR**
Percutaneous antegrade removal of ureteral stones is an alternative when SWL is not indicated or has failed, and when the upper urinary tract is not amenable to retrograde URS.	A

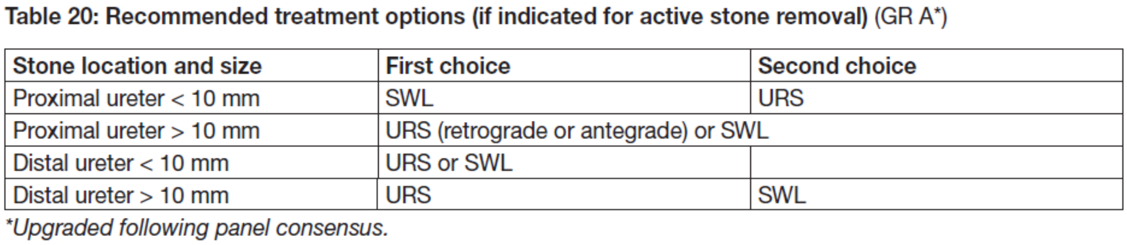
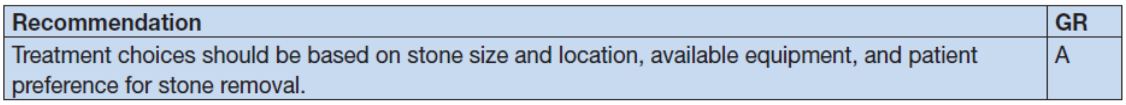


Table 20: Recommended treatment options (if indicated for active stone removal) (GR A*)

Stone location and size	**First choice**	**Second choice**
Proximal ureter < 10 mm	SWL	URS
Proximal ureter > 10 mm	URS (retrograde or antegrade) or SWL	
Distal ureter < 10 mm	URS or SWL	
Distal ureter > 10 mm	URS	SWL

**Upgraded following panel consensus.*



Recommendation	**GR**
Treatment choices should be based on stone size and location, available equipment, and patient preference for stone removal.	A

Other methods for ureteral stone removal

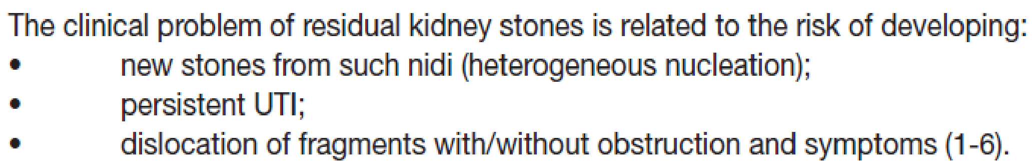
- laparoscopic stone removal
- open surgery

Reserved for special cases. These more invasive procedures have yielded high SFRs.

RESIDUAL STONES

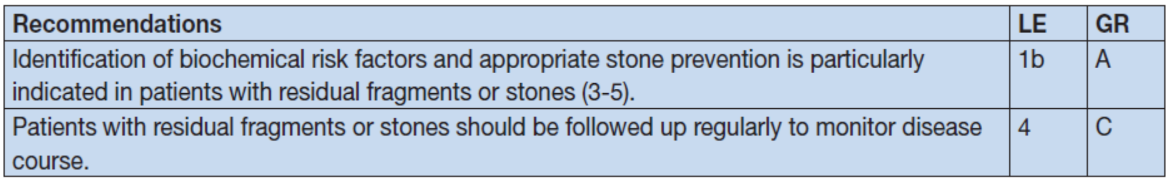
Clinical evidence

- Residual fragments are commonly seen in the kidney (mostly in the lower calix) after SWL and sometimes after intracorporeal lithotripsy.



The clinical problem of residual kidney stones is related to the risk of developing:

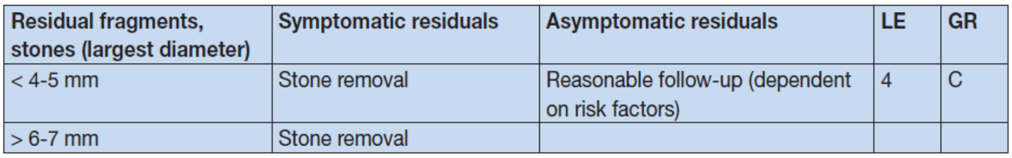
- new stones from such nidi (heterogeneous nucleation);
- persistent UTI;
- dislocation of fragments with/without obstruction and symptoms (1-6).



Recommendations	LE	GR
Identification of biochemical risk factors and appropriate stone prevention is particularly indicated in patients with residual fragments or stones (3-5).	1b	A
Patients with residual fragments or stones should be followed up regularly to monitor disease course.	4	C

- **Recurrence risk in patients with residual fragments after treatment of infection stones is higher than for other stones**.
- Fragments > 5 mm are more likely than smaller ones to require intervention

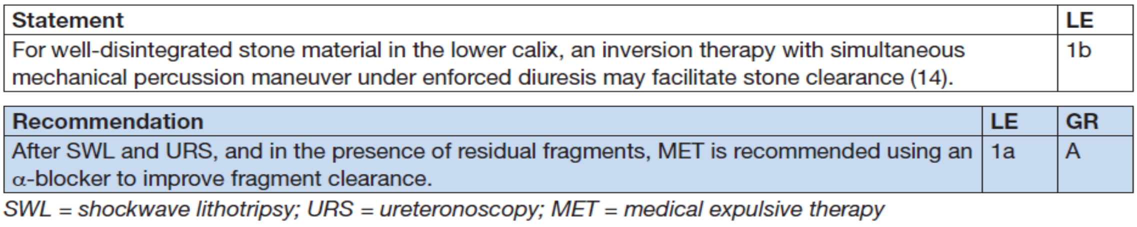
Table 21: Recommendations for the treatment of residual fragments



Residual fragments, stones (largest diameter)	Symptomatic residuals	Asymptomatic residuals	LE	GR
< 4-5 mm	Stone removal	Reasonable follow-up (dependent on risk factors)	4	C
> 6-7 mm	Stone removal			

Therapy

- Residual fragments after PNL can be avoided by a second look using the existing percutaneous tract 1-3 days after the first procedure. To facilitate further clearance, medical and physical adjunctive therapy can be suggested.
- The indications for active stone removal and selection of the procedure are based on the same criteria as for primary stone treatment and includes repeat SWL.
- If intervention is not required, medical therapy according to stone analysis, patient risk group, and metabolic evaluation might help to prevent regrowth of residual fragments



Statement	LE
For well-disintegrated stone material in the lower calix, an inversion therapy with simultaneous mechanical percussion maneuver under enforced diuresis may facilitate stone clearance (14).	1b

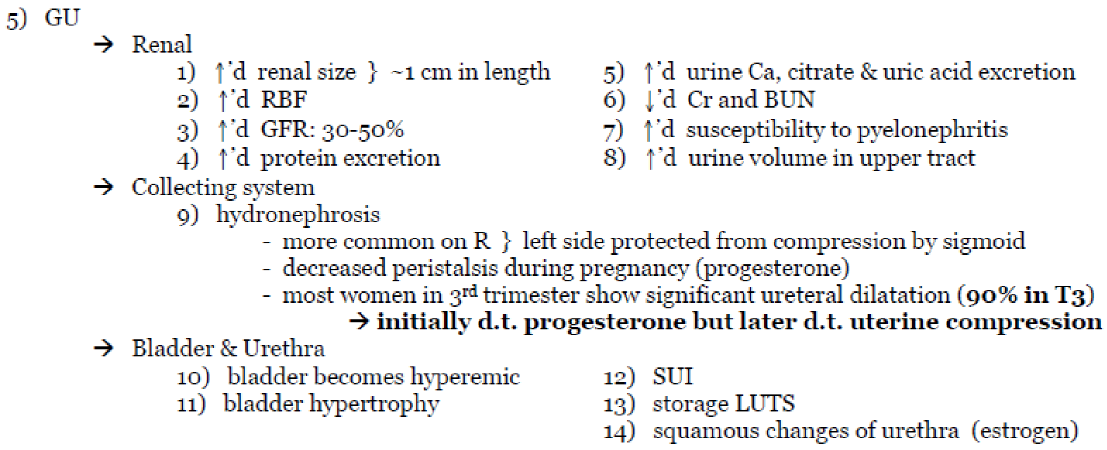
Recommendation	LE	GR
After SWL and URS, and in the presence of residual fragments, MET is recommended using an α-blocker to improve fragment clearance.	1a	A

SWL = shockwave lithotripsy; URS = ureteronoscopy; MET = medical expulsive therapy

Management of urinary stones
and related problems during pregnancy

- Urolithiasis during pregnancy is a diagnostic and therapeutic challenge. In most cases, it becomes symptomatic in the second or third trimester.

Physiologic changes in pregnancy:

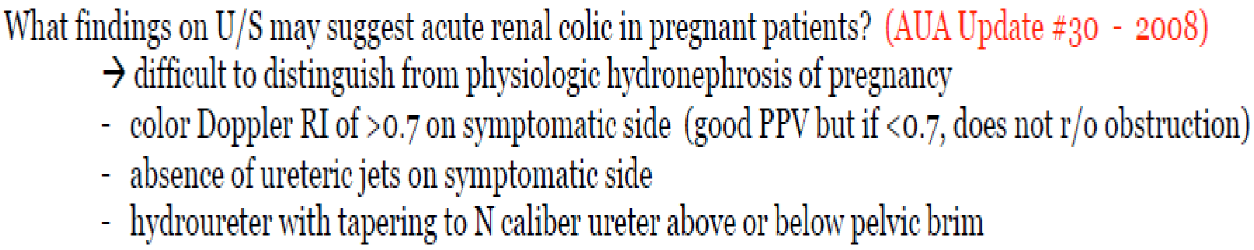


5) GU
  → Renal
    1) ↑'d renal size } ~1 cm in length
    2) ↑'d RBF
    3) ↑'d GFR: 30-50%
    4) ↑'d protein excretion
    5) ↑'d urine Ca, citrate & uric acid excretion
    6) ↓'d Cr and BUN
    7) ↑'d susceptibility to pyelonephritis
    8) ↑'d urine volume in upper tract
  → Collecting system
    9) hydronephrosis
      - more common on R } left side protected from compression by sigmoid
      - decreased peristalsis during pregnancy (progesterone)
      - most women in 3rd trimester show significant ureteral dilatation (**90% in T3**)
        → **initially d.t. progesterone but later d.t. uterine compression**
  → Bladder & Urethra
    10) bladder becomes hyperemic
    11) bladder hypertrophy
    12) SUI
    13) storage LUTS
    14) squamous changes of urethra (estrogen)

Diagnostic imaging

- Diagnostic options in pregnant women are limited due to the possible teratogenic, carcinogenic, and mutagenic risk of foetal radiation exposure.
- The risk for the child crucially depends on gestational age and amount of radiation delivered.
- **X-ray** imaging during the first trimester should be **avoided and reserved** for diagnostic and therapeutic situations in which alternative imaging methods have failed.
- **Ultrasound** (when necessary using change in renal resistive index and transvaginal/transabdominal US with a full bladder) has

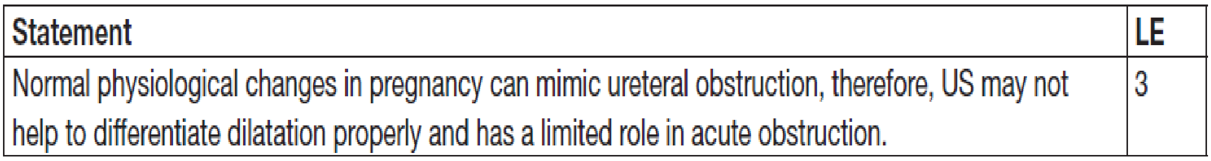
become the primary radiological diagnostic tool when evaluating pregnant patients suspected of renal colic



What findings on U/S may suggest acute renal colic in pregnant patients? (AUA Update #30 - 2008)

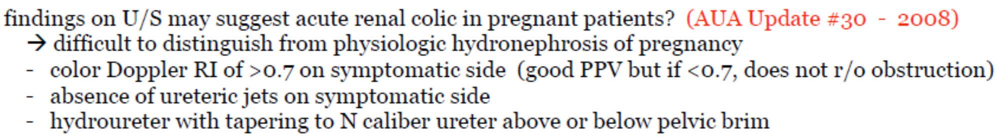
→ difficult to distinguish from physiologic hydronephrosis of pregnancy

- color Doppler RI of >0.7 on symptomatic side (good PPV but if <0.7, does not r/o obstruction)
- absence of ureteric jets on symptomatic side
- hydroureter with tapering to N caliber ureter above or below pelvic brim



Statement	LE
Normal physiological changes in pregnancy can mimic ureteral obstruction, therefore, US may not help to differentiate dilatation properly and has a limited role in acute obstruction.	3

- X-ray imaging options in pregnancy are:
    - **limited excretory urography** and **NCCT** (considering the higher dose of radiation exposure).



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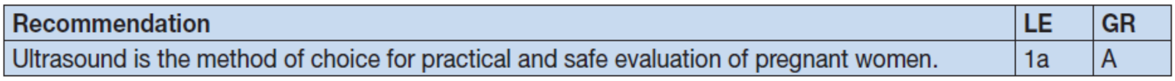
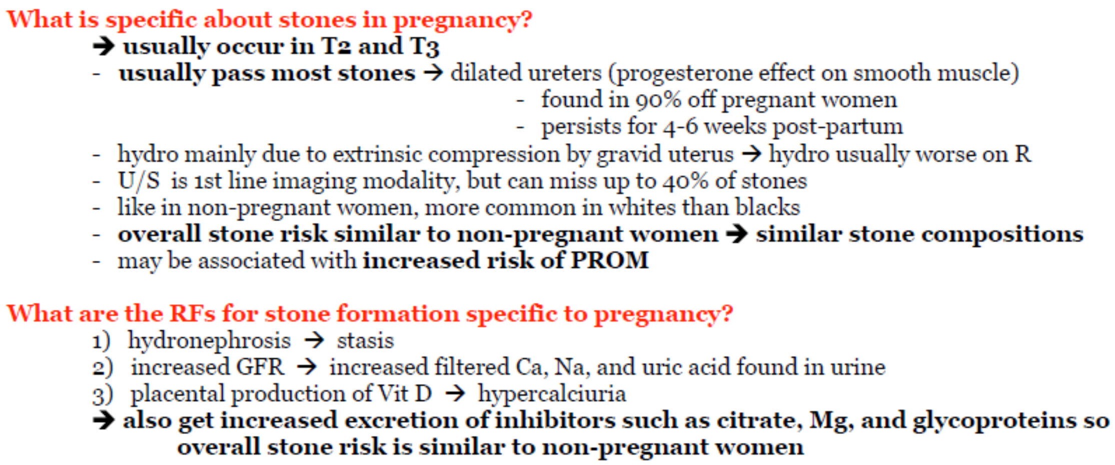
-

- **Magnetic resonance urography (MRU)** can be used to define the level of urinary tract obstruction, and to visualize stones as a filling defect. MRU studies avoid ionising radiation and iodinated contrast medium.



Recommendation	LE	GR
Ultrasound is the method of choice for practical and safe evaluation of pregnant women.	1a	A



What is specific about stones in pregnancy?

→ **usually occur in T2 and T3**
- **usually pass most stones** → dilated ureters (progesterone effect on smooth muscle)
    - found in 90% off pregnant women
    - persists for 4-6 weeks post-partum
- hydro mainly due to extrinsic compression by gravid uterus → hydro usually worse on R
- U/S is 1st line imaging modality, but can miss up to 40% of stones
- like in non-pregnant women, more common in whites than blacks
- **overall stone risk similar to non-pregnant women → similar stone compositions**
- may be associated with **increased risk of PROM**

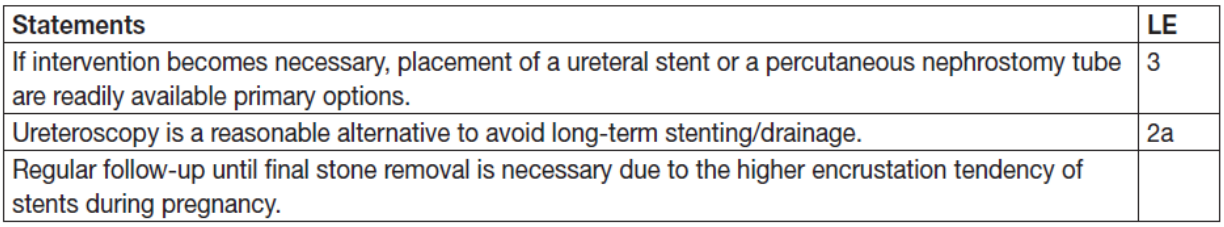
What are the RFs for stone formation specific to pregnancy?

1) hydronephrosis → stasis
2) increased GFR → increased filtered Ca, Na, and uric acid found in urine
3) placental production of Vit D → hypercalciuria

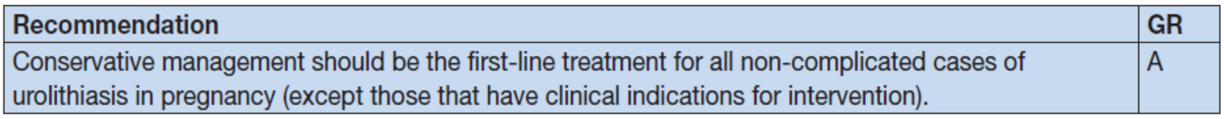
→ **also get increased excretion of inhibitors such as citrate, Mg, and glycoproteins so overall stone risk is similar to non-pregnant women**

Management

- Clinical management of a pregnant urolithiasis patient is complex.
- Approximately 70-80% of the symptomatic stones pass spontaneously.
- If spontaneous passage does not occur, or if complications develop (e.g., induction of premature labour) → **placement of a ureteral stent** or **a percutaneous nephrostomy** tube is necessary.
    - often associated with poor tolerance, and they require multiple exchanges during pregnancy, due to the potential for rapid encrustation.
- **Ureteroscop**y has become a reasonable alternative in these situations.
- Although feasible, retrograde endoscopic and percutaneous stone removal procedures during pregnancy remain an individual decision and should be performed only in experienced centres
- **Pregnancy remains an absolute contraindication for SWL**



Statements	LE
If intervention becomes necessary, placement of a ureteral stent or a percutaneous nephrostomy tube are readily available primary options.	3
Ureteroscopy is a reasonable alternative to avoid long-term stenting/drainage.	2a
Regular follow-up until final stone removal is necessary due to the higher encrustation tendency of stents during pregnancy.	



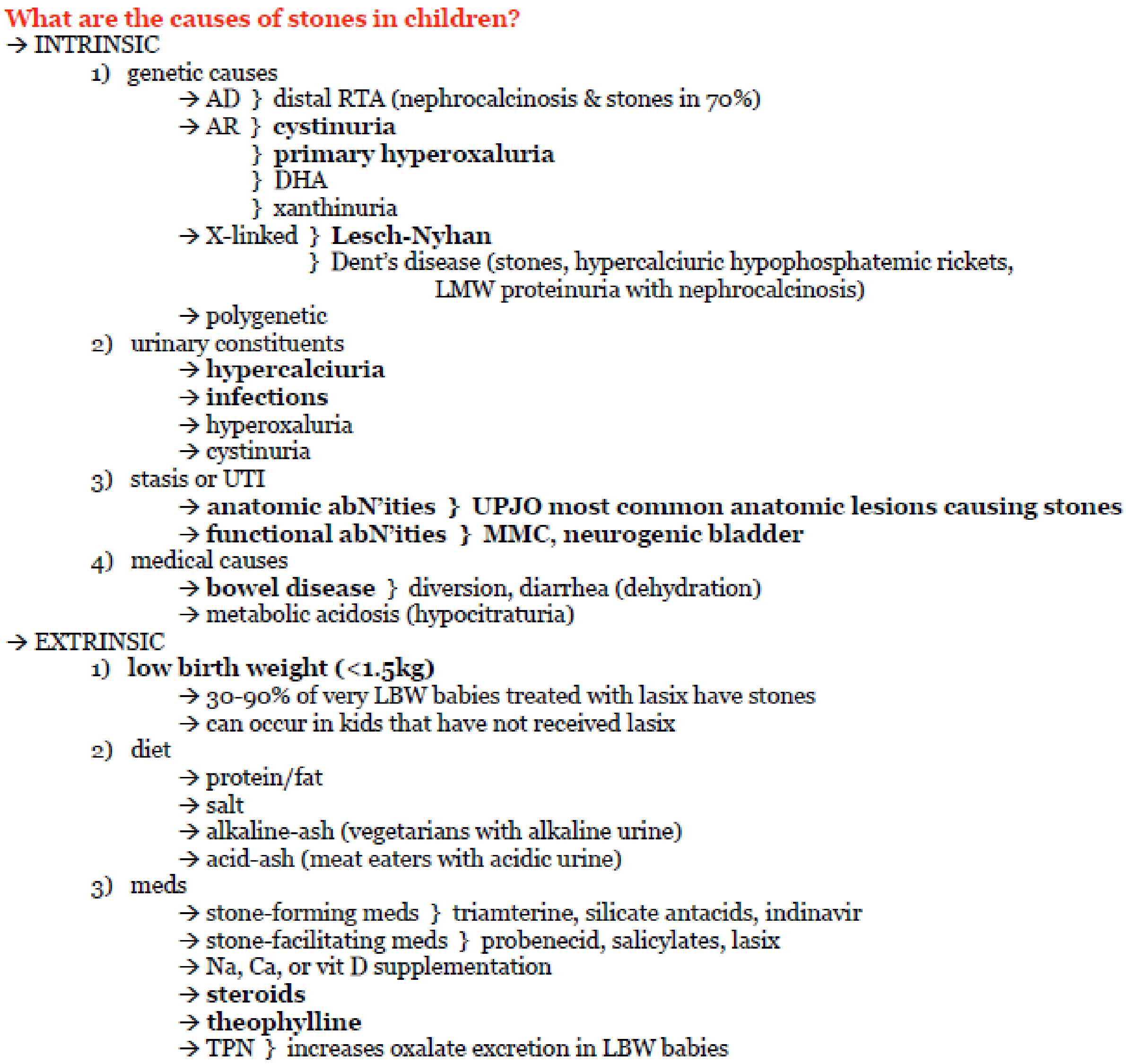
Recommendation	GR
Conservative management should be the first-line treatment for all non-complicated cases of urolithiasis in pregnancy (except those that have clinical indications for intervention).	A

Summary of management

What is the medical management of stones during pregnancy?

- **no increased risk of stone formation → urine Ca increases BUT so does urine citrate**
- **no role for metabolic w/u until after delivery when physiologic changes normalize**
- U/S is first line imaging modality
  - → hard to see distal ureters
  - → hydro of pregnancy may be confused with obstruction
- threshold of radiation is 1.2 rad
  - → avoid radiation esp in T1 (organogenesis)
- limited IVP (scout + 30 sec + 20-30mins) can be done
  - → each film is 0.1 to 0.2 rad
- 66-85% of pregnant women spontaneously pass stones if treated conservatively
  - → hydration + analgesics +/- ABx
- if stents needed, use minimal fluoro or use ultrasound
  - → stents can migrate down easier with dilated ureters
  - → stents encrust easier so should be changed q4-6 weeks
  - → **think of percutaneous NT if early in pregnancy (before 22wks)**
- URS + laser litho is safe
  - → avoid U/S lithotriptor } risk of fetal hearing loss
- **SWL contraindicated**

Management of stone problems in children



What are the causes of stones in children?

→ INTRINSIC
  1) genetic causes
    → AD } distal RTA (nephrocalcinosis & stones in 70%)
    → AR } **cystinuria**
      } **primary hyperoxaluria**
      } DHA
      } xanthinuria
    → X-linked } **Lesch-Nyhan**
      } Dent's disease (stones, hypercalciuric hypophosphatemic rickets, LMW proteinuria with nephrocalcinosis)
    → polygenetic
  2) urinary constituents
    → **hypercalciuria**
    → **infections**
    → hyperoxaluria
    → cystinuria
  3) stasis or UTI
    → **anatomic abN'ities } UPJO most common anatomic lesions causing stones**
    → **functional abN'ities } MMC, neurogenic bladder**
  4) medical causes
    → **bowel disease** } diversion, diarrhea (dehydration)
    → metabolic acidosis (hypocitraturia)

→ EXTRINSIC
  1) **low birth weight (<1.5kg)**
    → 30-90% of very LBW babies treated with lasix have stones
    → can occur in kids that have not received lasix
  2) diet
    → protein/fat
    → salt
    → alkaline-ash (vegetarians with alkaline urine)
    → acid-ash (meat eaters with acidic urine)
  3) meds
    → stone-forming meds } triamterine, silicate antacids, indinavir
    → stone-facilitating meds } probenecid, salicylates, lasix
    → Na, Ca, or vit D supplementation
    → **steroids**
    → **theophylline**
    → TPN } increases oxalate excretion in LBW babies

Paediatric stone disease is an important clinical problem in paediatric urology practice. More than 1% of all urinary stones seen in patients aged < 18 years

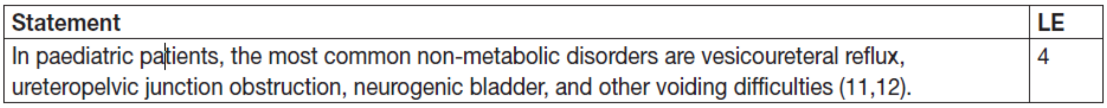
- As a result of malnutrition and racial factors, paediatric urolithiasis remains an endemic disease in some areas (e.g., Turkey and the Far East).
- Because of its recurrent nature, every effort should be made to discover the underlying metabolic abnormality so that it can be treated appropriately. Obtaining a stone-free state with

interventional management and close follow-up are of the utmost importance.

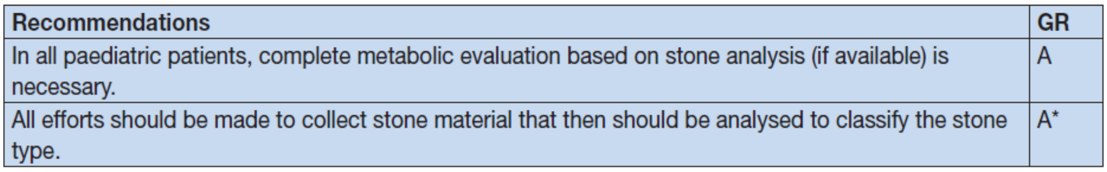
- Difference from adults:
  - boys and girls are affected almost equally (adults M>F).
  - Most paediatric stones are located in the upper urinary tract.
    - However, bladder stones are still common in underdeveloped areas of the world and are usually **ammonium acid urate** and **uric acid stones**, d.t dietary factors.
- The incidence and characteristics of stones show a wide geographical variation in children

Aetiology

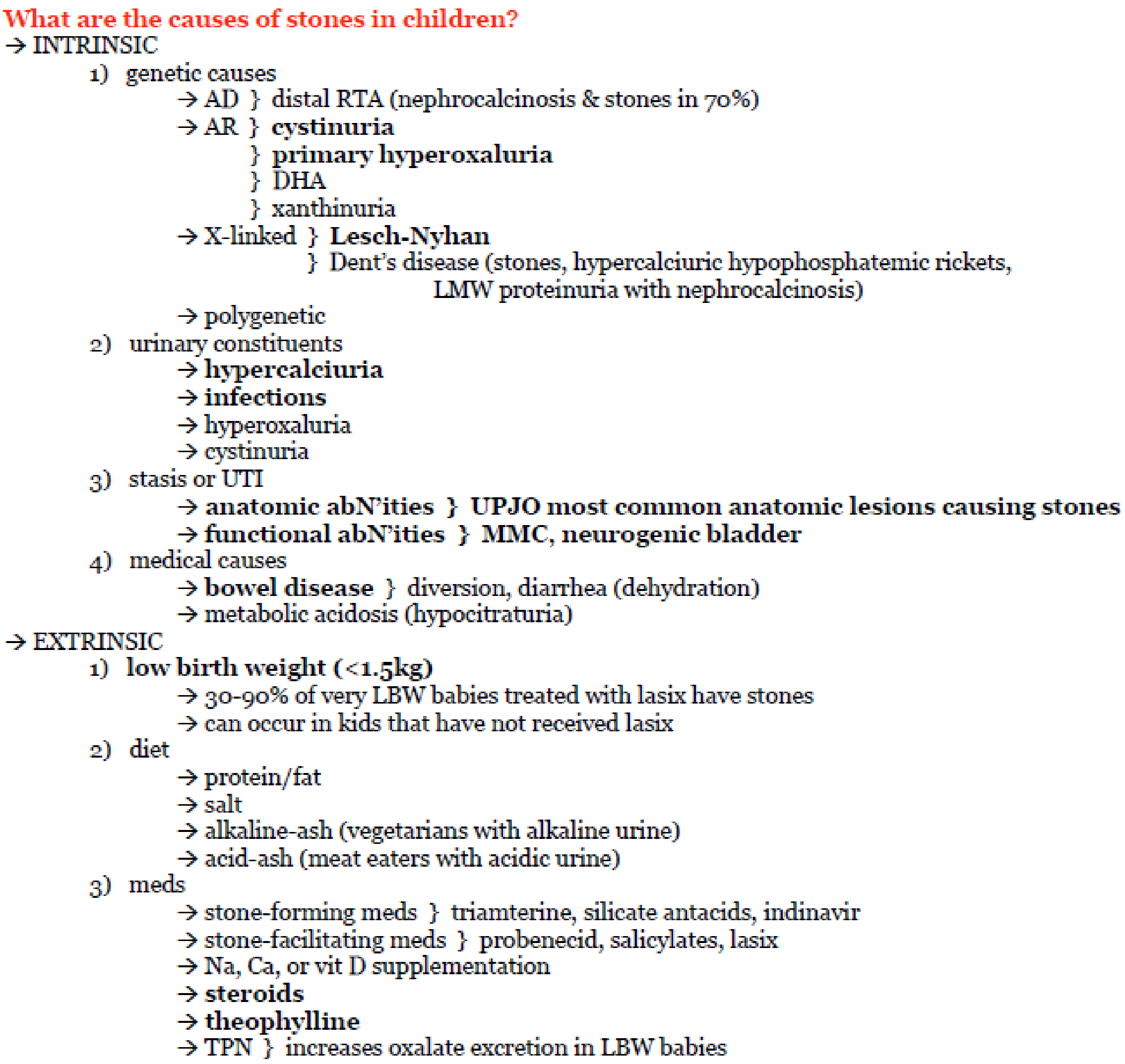
- Paediatric patients forming urinary stones have a high risk of recurrence, therefore, standard diagnostic procedures for high-risk patients apply



Statement	LE
In paediatric patients, the most common non-metabolic disorders are vesicoureteral reflux, ureteropelvic junction obstruction, neurogenic bladder, and other voiding difficulties (11,12).	4



Recommendations	GR
In all paediatric patients, complete metabolic evaluation based on stone analysis (if available) is necessary.	A
All efforts should be made to collect stone material that then should be analysed to classify the stone type.	A*



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Diagnostic imaging

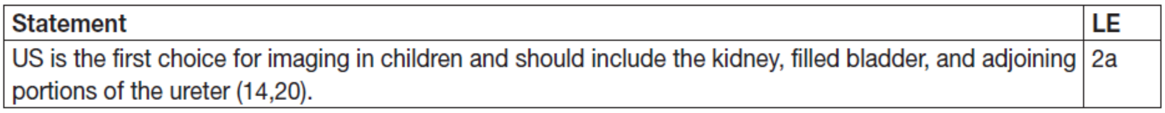
- children might be uncooperative, require anaesthesia, or be sensitive to ionising radiation.
- **It consists of both imaging and metabolic evaluation**.

Imaging

Ultrasound

- Ultrasound (US) is the primary imaging technique in paediatrics.
- Advantages:
  - absence of radiation and no need for anaesthesia.

    - provides information about the presence, size and location of a stone, and the grade of dilatation/obstruction of the urinary collecting system and the severity of nephrocalcinosis.
    - Also indicates anatomical abnormalities.
- ***Colour Doppler US*** shows differences in the ureteric jet and resistive index of the arciform arteries of both kidneys, which are indicative of the grade of obstruction.
- Disadvantage:
    - fails to identify stones in > 40% of paediatric patients and provides no information about renal function.



Statement	**LE**
US is the first choice for imaging in children and should include the kidney, filled bladder, and adjoining portions of the ureter (14,20).	2a

Plain films (KUB radiography)

KUB radiography can help to identify stones and their radiopacity, and facilitate follow-up.

Intravenous urography (IVU)

Intravenous urography is an important diagnostic tool. However, the need for contrast medium injection is a major drawback. The radiation dose for IVU is comparable to that for voiding cystourethrography (0.33 mSV).

Helical computed tomography (CT)

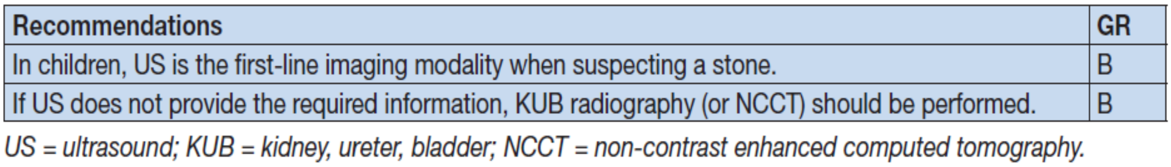
- Recent CT protocols have been shown to reduce radiation exposure significantly. The principle of **ALARA** (as low as reasonable achievable) should always be observed.
- In adults it has a sensitivity of 95-100% and specificity of 92-100%. In children, only 5% of stones escape detection by NCCT. Sedation or anaesthesia is rarely needed with modern high-speed CT apparatus.

Magnetic resonance urography (MRU)

- cannot be used to detect urinary stones.
- might provide detailed anatomical information about the urinary collecting system, the location of an obstruction or stenosis in the ureter, and renal parenchymal morphology.

Nuclear imaging

- 99mTc-dimercaptosuccinyl acid scanning provides information about cortical abnormalities such as scarring, but does not aid primary diagnosis of urolithiasis.
- Diuretic renography with injection of a radiotracer (MAG3 [Mercaptoacetyltriglycin] or DPTA [Diethylentriaminpentaacetat]) and furosemide can be used to demonstrate renal function, identify obstruction in the kidney after injection of furosemide, and indicate the anatomical level of the obstruction



Recommendations	GR
In children, US is the first-line imaging modality when suspecting a stone.	B
If US does not provide the required information, KUB radiography (or NCCT) should be performed.	B

US = ultrasound; KUB = kidney, ureter, bladder; NCCT = non-contrast enhanced computed tomography.

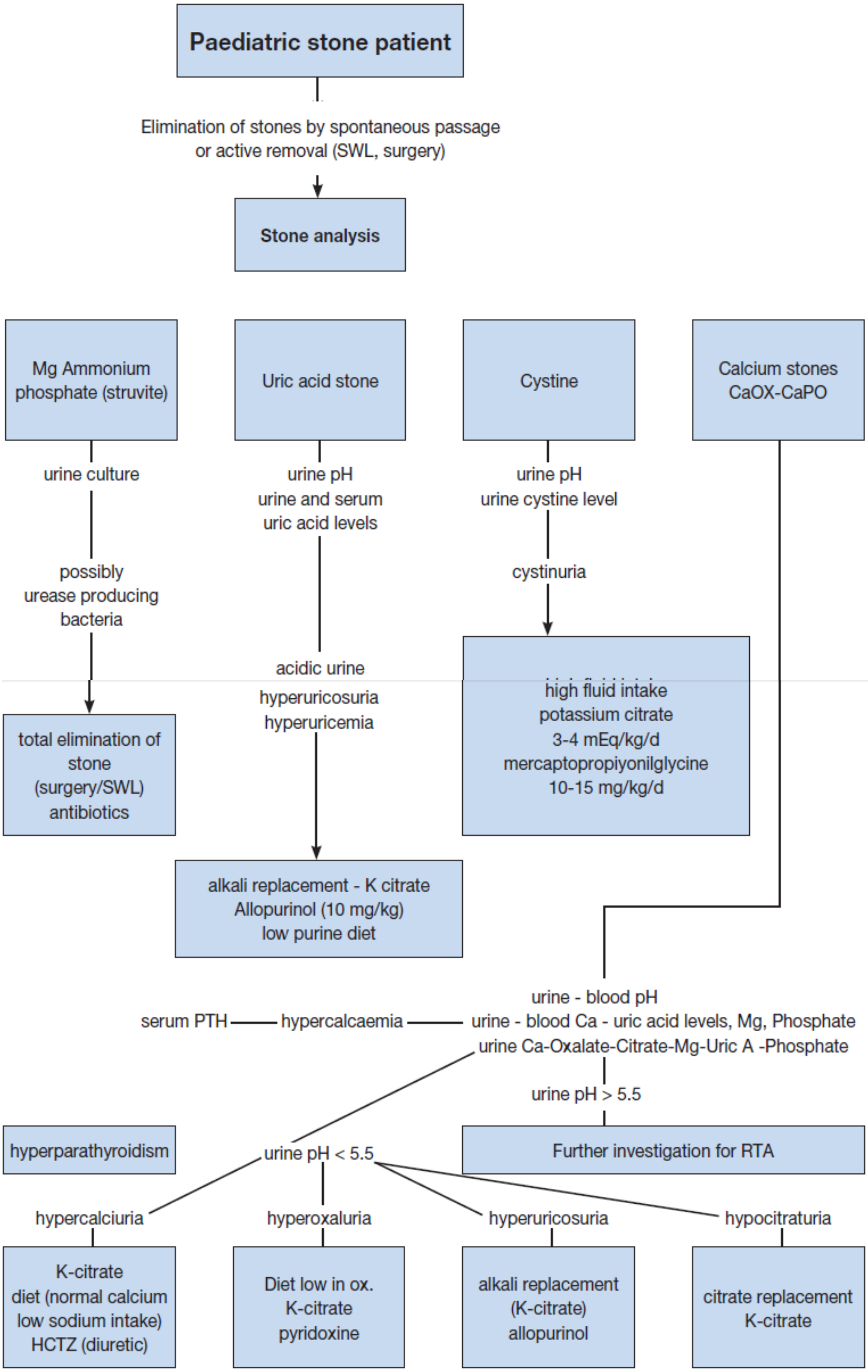
Metabolic evaluation

- ➢ Due to the high incidence of predisposing factors for urolithiasis in children and high stone recurrence rates, every child with urinary stone should be given a complete metabolic evaluation.

- Metabolic evaluation includes:

  - Family and patient history of metabolic problems.
  - Analysis of **stone** composition (following stone analysis, metabolic evaluation can be modified according to the specific stone type).
  - **Electrolytes**, BUN, creatinine, calcium, phosphorus, alkaline phosphatase, uric acid, total protein, carbonate, albumin, and parathyroid hormone (if there is hypercalcaemia).
  - Spot urinalysis and culture, including ratio of calcium to creatinine.
  - Urine tests, including a 24-hour urine collection for calcium, phosphorus, magnesium, oxalate, uric acid citrate, cystine, protein, and creatinine clearance.

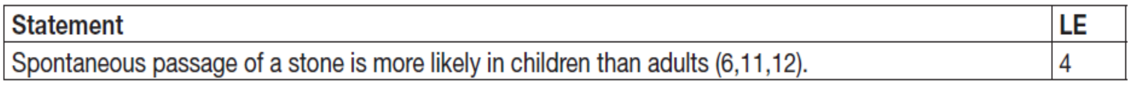
Figure 4: Algorithm for metabolic investigations in urinary stone disease in childeren



SWL = extracorporeal shockwave lithotripsy; HCTZ = hydrochlorothiazide; PTH = parathyroid hormone; RTA = renal tubular acidosis

Stone removal

- Several factors must be considered when selecting treatment procedures for children. Compared to adults, children pass fragments more rapidly after SWL.
- For endourological procedures, the smaller organs in children must be considered when selecting instruments for PNL or URS.
- Anticipation of the expected stone composition should be taken into account when selecting the appropriate procedure for stone removal (cystine stones are more resistant to SWL).



Statement	LE
Spontaneous passage of a stone is more likely in children than adults (6,11,12).	4

Medical expulsive therapy (MET) in children

- Although the use of α-blockers is very common in adults, there are insufficient data to demonstrate their safety and efficacy in children

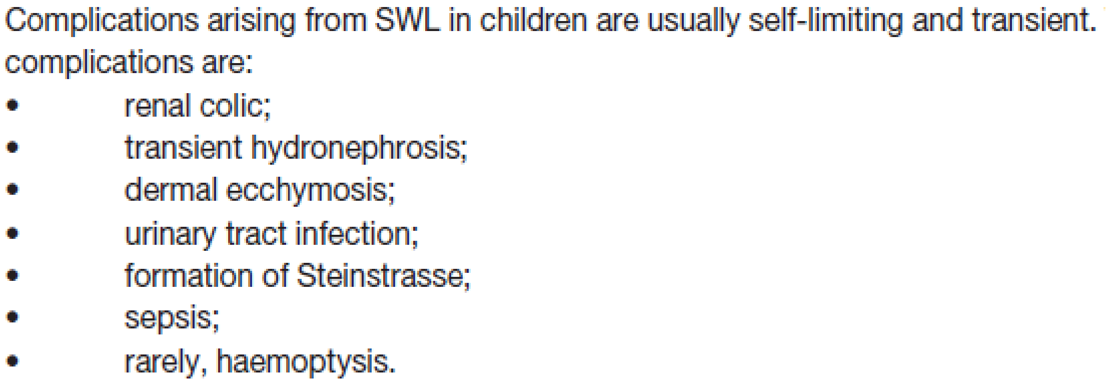
Extracorporeal shock wave lithotripsy

- Extracorporeal shock wave lithotripsy remains least-invasive procedure for stone management in children.
- SFRs of 65-95% in short-term and 55-90% in long-term follow-up studies have been reported.
- **In children, compared with adults, SWL can achieve more effective disintegration of large stones,** together with swifter and uncomplicated discharge of large fragments.
- Stones located in calices, as well as abnormal kidneys, and large stones, are more difficult to disintegrate and clear.

    - The likelihood of urinary obstruction is higher in such cases, and children should be followed closely for the prolonged risk of urinary tract obstruction.
- The need for general anaesthesia during SWL depends on patient age and the lithotripter used.
    - General or dissociative anaesthesia is administered in most children aged < 10 years, to avoid patient and stone motion and the need for repositioning.
    - With modern lithotriptors, intravenous sedation or patient-controlled analgesia have been used in selected cooperative older children.
- Shockwave lithotripsy can also be used to treat ureteral calculi. However, this is a more specific issue and with controversies. The success rates with SWL are less for distal ureteric stones. There may also be technical problems with localisation and focusing of ureteric stones in children
- There are concerns regarding the safety and potential biological effects of SWL on immature kidneys and surrounding organs in children.
    - However, no irreversible functional or morphological side effects of high-energy shock waves have been demonstrated.
    - In addition, when the potential deterioration of renal function is taken into account (although transient), restricting the number of shock waves and the energy used during each treatment session helps protect the kidneys.
- Stone-free rates are significantly affected by various factors.
    - Regardless of the location, as the stone size increases, the stone-free rates decrease and re-treatment rate increases. The

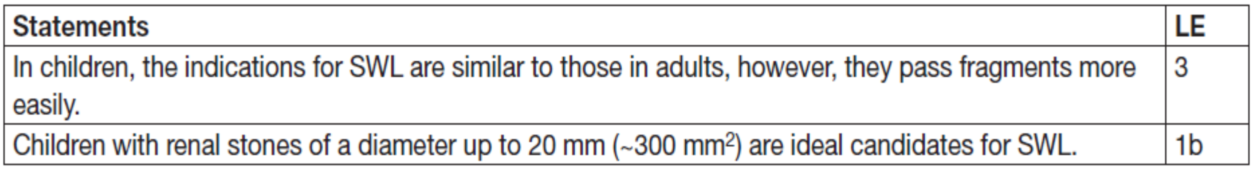
stone-free rates for < 1 cm, 1-2 cm, > 2 cm and overall, were reported as nearly 90%, 80%, 60% and 80%, respectively.

- The mean number of shock waves for each treatment is about 1800 and 2000 (up to 4000 if needed) and the mean power set varies between 14 kV and 21 kV.
- The use of ultrasonography and digital fluoroscopy has significantly decreased the radiation exposure and it has been shown that children are exposed to significantly lower doses of radiation compared to adults
- If the stone burden requires a ureteral stent, alternative procedures should be considered.
    - Ureteral stents are seldom needed following SWL of upper tract stones, ureteral pre-stenting decreases the SFR after initial treatment



Complications arising from SWL in children are usually self-limiting and transient. complications are:

- renal colic;
- transient hydronephrosis;
- dermal ecchymosis;
- urinary tract infection;
- formation of Steinstrasse;
- sepsis;
- rarely, haemoptysis.



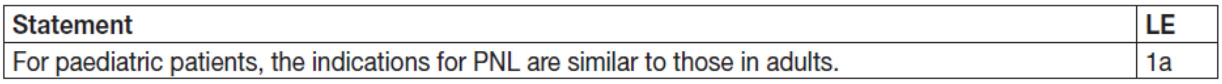
Statements	**LE**
In children, the indications for SWL are similar to those in adults, however, they pass fragments more easily.	3
Children with renal stones of a diameter up to 20 mm (~300 mm^2) are ideal candidates for SWL.	1b

Endourological procedures

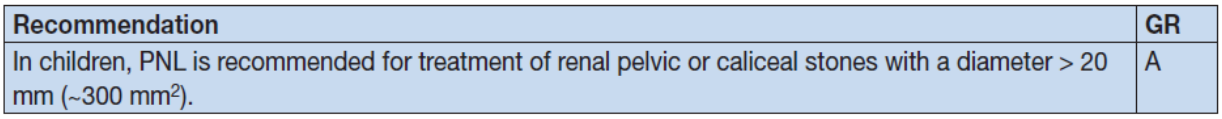
Improvement in intracorporeal lithotripsy devices and development of smaller instruments facilitate PNL and URS in children.

Percutaneous nephrolithotripsy (PNL)

- Preoperative evaluation and indications for PNL in children are similar to those in adults.
- Although PNL is performed as monotherapy in most cases, it can be used as an adjunctive procedure.
- Availability of appropriate-size instruments and US guidance mean that age is not a limiting factor, and PNL can now be performed safely by experienced operators, with less radiation exposure, even for large and complex stones.
- SFRs are between 70% -100% after a single session, and increase with adjunctive measures, as second-look PNL, SWL and URS



Statement	LE
For paediatric patients, the indications for PNL are similar to those in adults.	1a

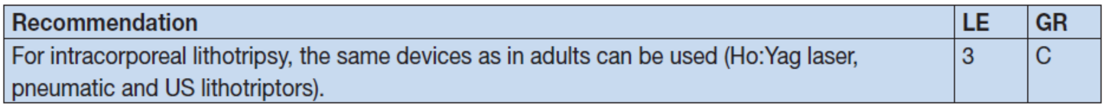


Recommendation	GR
In children, PNL is recommended for treatment of renal pelvic or caliceal stones with a diameter > 20 mm (~300 mm^2).	A

Ureteroscopy

- Although SWL still is the first-line treatment for most ureteral stones, it is unlikely to be successful for:
    - stones > 10 mm in diameter,
    - Impacted stones,
    - calcium oxalate monohydrate or cystine stones, or
    - stones in children with unfavourable anatomy and whom localisation is difficult.

- If SWL is not promising, ureteroscopy can be used. With the clinical introduction of smaller-calibre instruments, this modality has **become the treatment of choice for medium and larger distal ureteric stones in children**
- Different lithotripsy techniques, including ultrasonic, pneumatic and laser lithotripsy, are all safe and effective



Recommendation	LE	GR
For intracorporeal lithotripsy, the same devices as in adults can be used (Ho:Yag laser, pneumatic and US lithotriptors).	3	C

- Flexible ureteroscopy has become an efficacious treatment for paediatric upper urinary tract stones. It is particularly effective for treatment of proximal ureteral calculi and stones < 1.5 cm in the lower pole calices

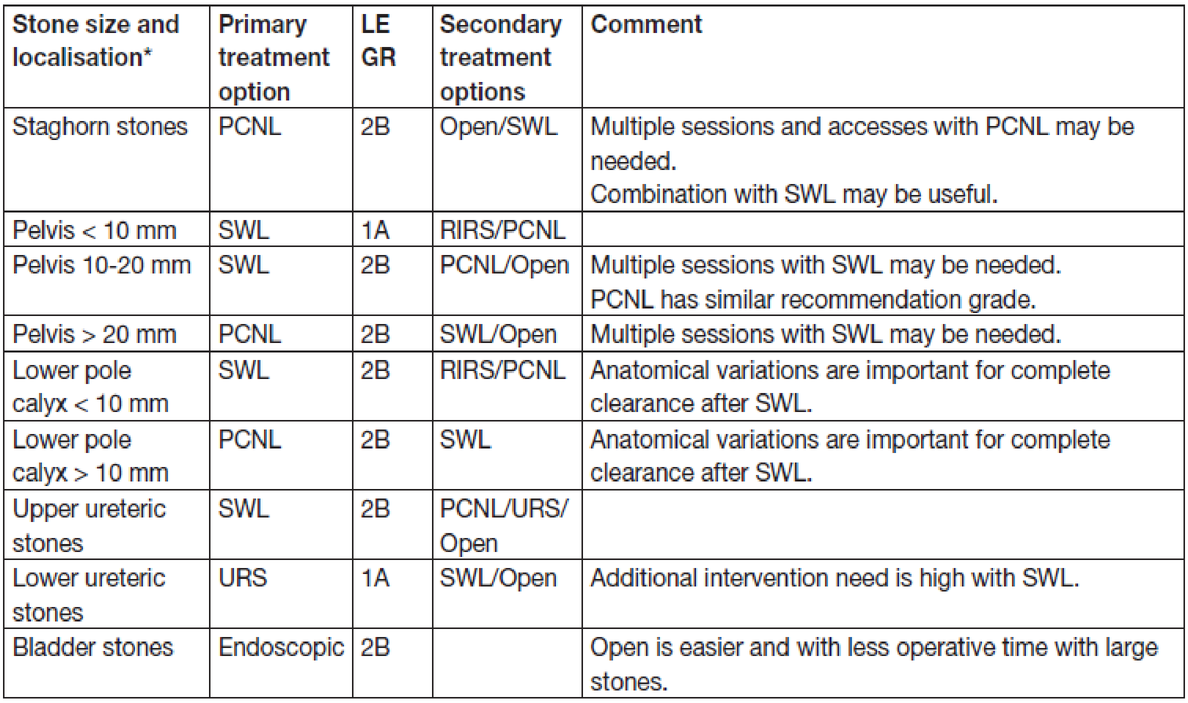
Open or laparoscopic surgery

- Most stones in children can be managed by SWL and endoscopic techniques
- Therefore, the rate of open procedure has dropped significantly.
- Indications for surgery include:
    - failure of primary therapy for stone removal;
    - very young children with complex stones;
    - congenital obstruction requiring simultaneous surgical correction;
    - severe orthopaedic deformities that limit positioning for endoscopic procedures; and
    - abnormal kidney position
- Open surgery can be replaced by laparoscopic procedures in experienced hands (62-64).

Special considerations on recurrence prevention

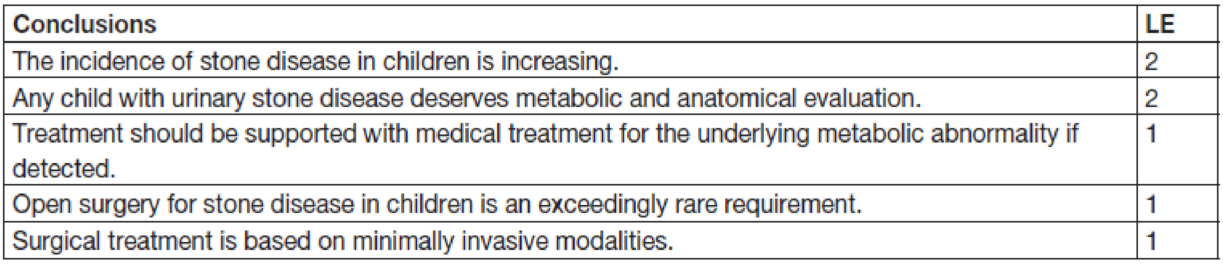
- All paediatric stone formers need metabolic evaluation and recurrence prevention with respect to the detected stone type.
- In case of obstructive pathology in association with the established metabolic abnormalities, treatment should not be delayed. Children are in the high-risk group for stone recurrence

Table 11: Recommendations for interventional management in paediatric stones

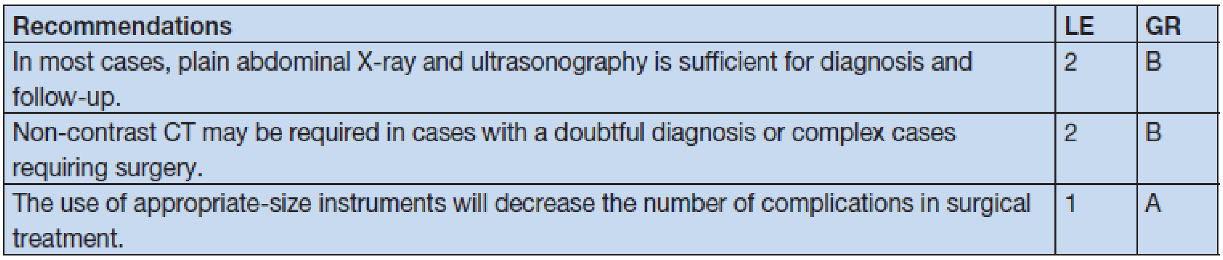


Stone size and localisation*	Primary treatment option	LE GR	Secondary treatment options	Comment
Staghorn stones	PCNL	2B	Open/SWL	Multiple sessions and accesses with PCNL may be needed. Combination with SWL may be useful.
Pelvis < 10 mm	SWL	1A	RIRS/PCNL	
Pelvis 10-20 mm	SWL	2B	PCNL/Open	Multiple sessions with SWL may be needed. PCNL has similar recommendation grade.
Pelvis > 20 mm	PCNL	2B	SWL/Open	Multiple sessions with SWL may be needed.
Lower pole calyx < 10 mm	SWL	2B	RIRS/PCNL	Anatomical variations are important for complete clearance after SWL.
Lower pole calyx > 10 mm	PCNL	2B	SWL	Anatomical variations are important for complete clearance after SWL.
Upper ureteric stones	SWL	2B	PCNL/URS/ Open	
Lower ureteric stones	URS	1A	SWL/Open	Additional intervention need is high with SWL.
Bladder stones	Endoscopic	2B		Open is easier and with less operative time with large stones.

15.6 Conclusions and recommendations



Conclusions	LE
The incidence of stone disease in children is increasing.	2
Any child with urinary stone disease deserves metabolic and anatomical evaluation.	2
Treatment should be supported with medical treatment for the underlying metabolic abnormality if detected.	1
Open surgery for stone disease in children is an exceedingly rare requirement.	1
Surgical treatment is based on minimally invasive modalities.	1



Recommendations	LE	GR
In most cases, plain abdominal X-ray and ultrasonography is sufficient for diagnosis and follow-up.	2	B
Non-contrast CT may be required in cases with a doubtful diagnosis or complex cases requiring surgery.	2	B
The use of appropriate-size instruments will decrease the number of complications in surgical treatment.	1	A

Stones in urinary diversion and other voiding problems

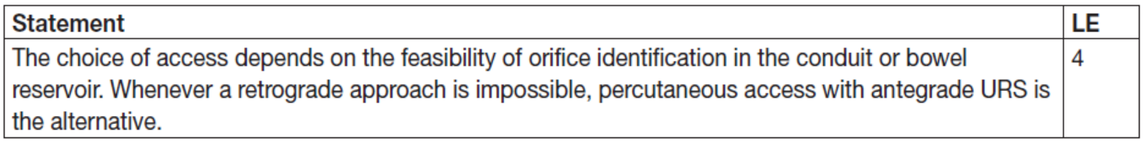
Management of stones in patients with urinary diversion

Aetiology

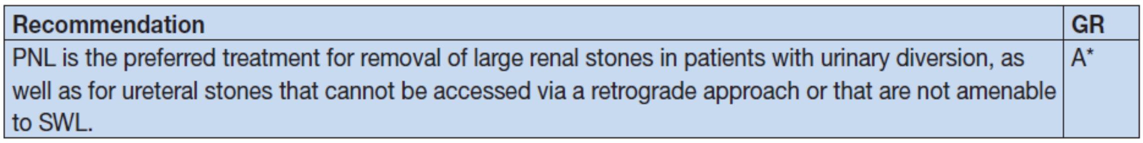
- Patients with urinary diversion are at high risk for stone formation in the renal collecting system and ureter or in the conduit or continent reservoir.
- Factors responsible for stone formation:
    - Metabolic factors (hypercalciuria, hyperoxaluria and hypocitraturia),
    - infection with urease-producing bacteria,
    - foreign bodies,
    - mucus secretion, and
    - urinary stasis.

Management

- Some patients with smaller upper-tract stones can be treated effectively with SWL but in the majority, other endourological techniques are necessary to achieve stone-free status
- An endoscopic approach might be difficult or impossible in individuals with long, tortuous conduits or invisible ureter orifices.



Statement	LE
The choice of access depends on the feasibility of orifice identification in the conduit or bowel reservoir. Whenever a retrograde approach is impossible, percutaneous access with antegrade URS is the alternative.	4



Recommendation	GR
PNL is the preferred treatment for removal of large renal stones in patients with urinary diversion, as well as for ureteral stones that cannot be accessed via a retrograde approach or that are not amenable to SWL.	A*

- For stones in the conduit, a trans-stomal approach can be used to remove all stone material (along with the foreign body) using standard techniques, including intracorporeal lithotripsy and flexible endoscopes.

- The same applies for continent urinary diversion where trans-stomal manipulations must be performed carefully to avoid disturbance of the continence mechanism
- Before considering any percutaneous approach in these cases, CT should be undertaken to assess the presence of an overlying bowel, which could make this approach unsafe, and if present, an open surgical approach should be considered.

Prevention

- Recurrence risk is high in these patients.
- Close follow-up and metabolic evaluation are necessary to obtain the risk parameters for effective long-term prevention.
- Preventive measures include medical management of metabolic abnormalities, appropriate therapy of urinary infections, and hyperdiuresis or regular irrigation of continent reservoirs.

Management of stones in patients with neurogenic bladder

Aetiology, clinical presentation and diagnosis

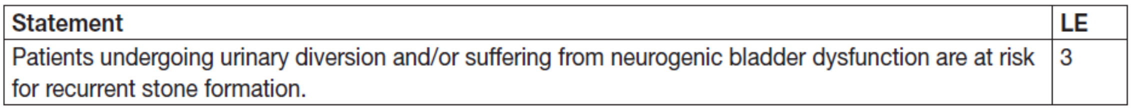
- Patients with neurogenic bladder develop urinary calculi because of additional risk factors such as bacteriuria, pelvicalicectasis, vesicoureteral reflux, renal scarring, lower urinary tract reconstruction, and thoracic spinal defect.
- The main issues are urinary stasis and infection. Indwelling catheters and surgical interposition of bowel segments for treatment of bladder dysfunction both facilitate UTI. Although

calculi can form at any level of the urinary tract, they occur more frequently in the bladder; especially if bladder augmentation has been performed.

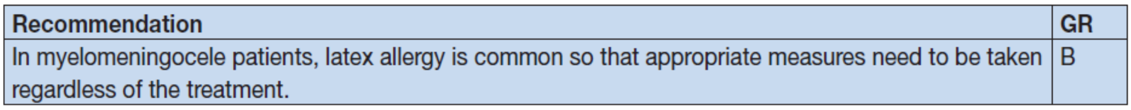
- Diagnosis of stones may be difficult and late in the absence of clinical symptoms due to sensory impairment and vesicourethral dysfunction. Difficulties in self-catheterisation should lead to suspicion of bladder calculi.

Management

- In MMC (myelomeningocele-) patients, latex allergy is common, therefore, appropriate measures need to be taken regardless of the treatment
    - Any surgery in these patients must be performed under general anaesthesia because of the impossibility of using spinal anaesthesia. Bone deformities often complicate positioning on the operating table.
- The risk of stone formation after augmentation cystoplasty in immobile patients with sensory impairment can be significantly reduced by irrigation protocols.
- For efficient long-term stone prevention in patients with neurogenic bladder, correction of the metabolic disorder, appropriate infection control, and restoration of normal storing/voiding function of the bladder are needed.



Statement	LE
Patients undergoing urinary diversion and/or suffering from neurogenic bladder dysfunction are at risk for recurrent stone formation.	3



Recommendation	GR
In myelomeningocele patients, latex allergy is common so that appropriate measures need to be taken regardless of the treatment.	B

Management of stones in transplanted kidneys

Aetiology and clinical presentation

- Transplant patients depend on their solitary kidney for renal function.
- Impairment causing urinary stasis/ obstruction therefore requires immediate intervention or drainage of the transplanted kidney. Risk factors in these patients are multifold:
  - Immunosuppression increases the infection risk, resulting in recurrent UTIs.
  - Hyperfiltration, excessively alkaline urine, renal tubular acidosis, and increased serum calcium caused by persistent tertiary hyperparathyroidism are biochemical risk factors.
- Stones in kidney allografts have a incidence of 0.2-1.7%

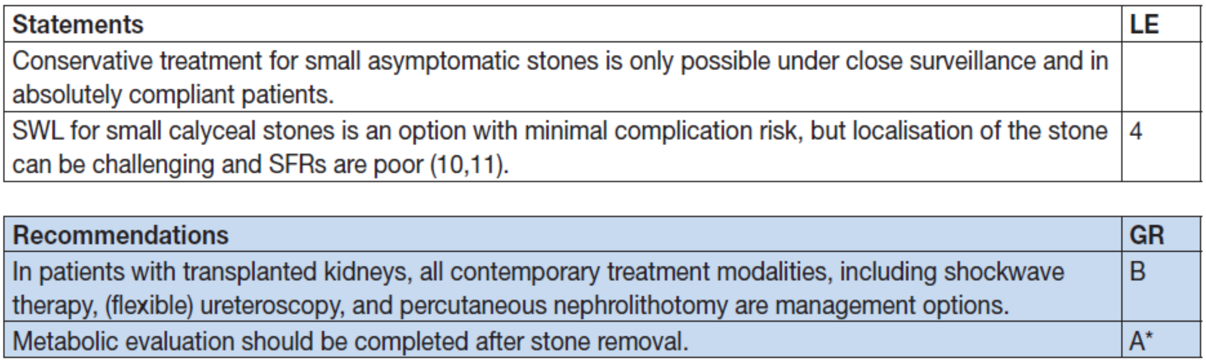
Recommendation	**LE**	**GR**
In patients with transplanted kidneys, unexplained fever, or unexplained failure to thrive, US or NCCT should be performed to rule out calculi (5).	4	B

Management

- Treatment decisions for selecting the appropriate technique for stone removal from a transplanted kidney are difficult.
- Although management principles are similar to those applied in other single renal units, additional factors such as transplant function, coagulative status, and anatomical obstacles due to the iliacal position of the organ, directly influence the surgical strategy.
- For large or ureteral stones, careful percutaneous access and subsequent antegrade endoscopy are more favourable.
- The introduction of small flexible ureteroscopes and holmium laser has made ureteroscopy a valid treatment option for transplant

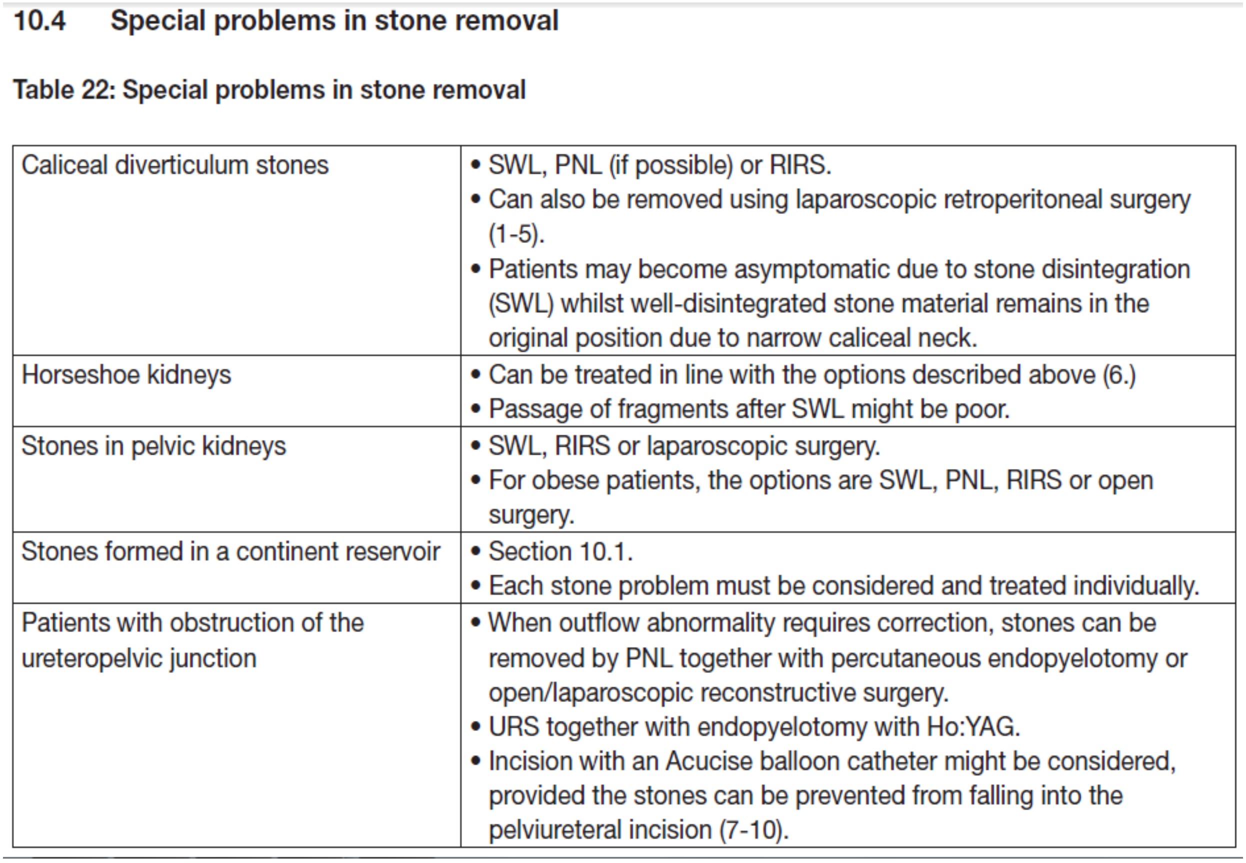
calculi. However, one must be aware of potential injury to adjacent organs.

- Retrograde access to transplanted kidneys is difficult due to the anterior location of the ureteral anastomosis, and ureteral tortuosity



Statements	LE
Conservative treatment for small asymptomatic stones is only possible under close surveillance and in absolutely compliant patients.	
SWL for small calyceal stones is an option with minimal complication risk, but localisation of the stone can be challenging and SFRs are poor (10,11).	4

Recommendations	GR
In patients with transplanted kidneys, all contemporary treatment modalities, including shockwave therapy, (flexible) ureteroscopy, and percutaneous nephrolithotomy are management options.	B
Metabolic evaluation should be completed after stone removal.	A*



10.4 Special problems in stone removal

Table 22: Special problems in stone removal

Caliceal diverticulum stones	• SWL, PNL (if possible) or RIRS. • Can also be removed using laparoscopic retroperitoneal surgery (1-5). • Patients may become asymptomatic due to stone disintegration (SWL) whilst well-disintegrated stone material remains in the original position due to narrow caliceal neck.
Horseshoe kidneys	• Can be treated in line with the options described above (6.) • Passage of fragments after SWL might be poor.
Stones in pelvic kidneys	• SWL, RIRS or laparoscopic surgery. • For obese patients, the options are SWL, PNL, RIRS or open surgery.
Stones formed in a continent reservoir	• Section 10.1. • Each stone problem must be considered and treated individually.
Patients with obstruction of the ureteropelvic junction	• When outflow abnormality requires correction, stones can be removed by PNL together with percutaneous endopyelotomy or open/laparoscopic reconstructive surgery. • URS together with endopyelotomy with Ho:YAG. • Incision with an Acucise balloon catheter might be considered, provided the stones can be prevented from falling into the pelviureteral incision (7-10).

Metabolic evaluation and recurrence prevention

General metabolic considerations for patient work-up

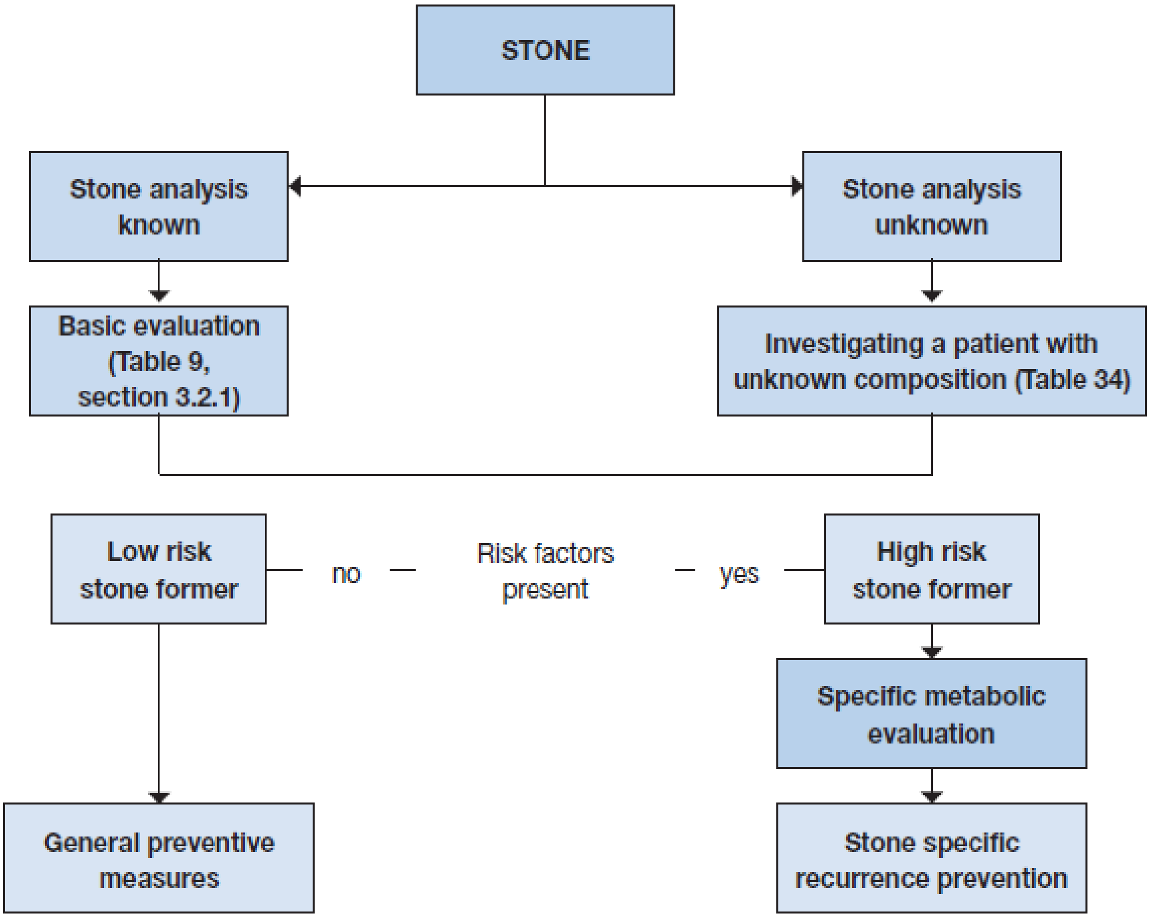
Evaluation of patient risk

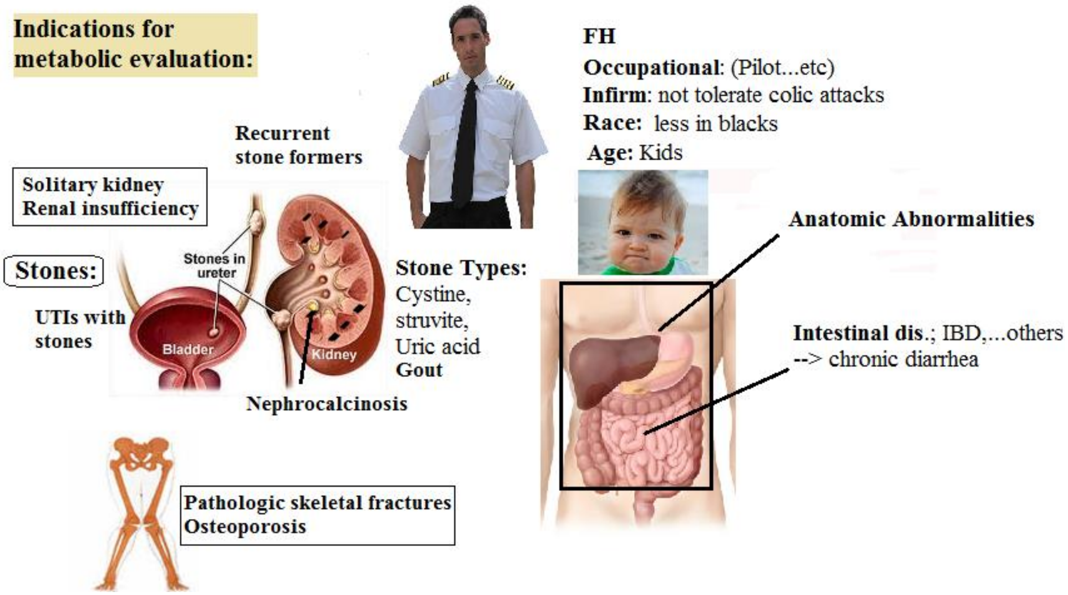
After stone passage, every patient should be assigned to a low- or high-risk group for stone formation (Figure below)

For correct classification 2 items:

- Reliable stone analysis (Infrared spectroscopy or X-ray diffraction)
- Basic evaluation

Figure 2: Assignment of patients to low- or high-risk groups for stone formation


STONE
Stone analysis known
Stone analysis unknown
Basic evaluation (Table 9, section 3.2.1)
Investigating a patient with unknown composition (Table 34)
Low risk stone former
no
Risk factors present
yes
High risk stone former
Specific metabolic evaluation
General preventive measures
Stone specific recurrence prevention



Simplified metabolic evaluation:

1. Hx & Physical

2. collect one or two -hr urine samples

    - no consensus on 1or 2
        - if 2 then one would be on usual diet, the other on a restricted diet
    - good collection (10-15mg/kg/day creat for F & 15-20mg/kg/ day creat for M

3. Urine for Ca, oxalate, uric acid, citrate, cystiue, pH, total volume, Na, Mg. K, sulfate
   (no fast and Ca load test)

4. Bloodwork
   CBC, lytes, BUN creat, intact PTH, Ca panel, uric acid

5. imaging

6. stone analysis (helps obviate need for complete metabolic work-up)

قراءة سريعة

What is the abbreviated evaluation of low-risk single stone formers (CHART)?

1) Hx → current presentation (pain, location, onset, quality, quantity, alleviating/aggravating factors, LUTs, hematuria, N/V, fever, chills, etc)
   → previous stone hx (episodes, when, how many, stone type, management, complications, etc)
   → underlying predisposing conditions (IBD, gout, osteoporosis, UTIs, malignancy, bowel Sx, etc)
   → meds (calcium, Vit C, Vit D, steroids, acetazolamide, antacids, chemo, ACEi), allergies
   → dietary hx (excessive red meat, inadequate fluid intake, excessive fluid losses, etc)
   → social hx (occupation, smoker, EtOH) and family hx
2) Physical Exam → general appearance
   → vitals (BP, temp)
   → abdo exam (masses, CVA tenderness, scars, DRE, etc)
   *** r/o need for immediate stent placement ***
3) **bloodwork → CBC, lytes, BUN, creatinine, Ca profile, intact PTH, uric acid**
   - primary hyperPTH (high calcium, low PO4)
   - renal phosphate leak (hypoPO4)
   - uric acid stones (hyperuricemia)
   - distal RTA (hypoK, acidosis)

   → β-hCG if fertile female
4) **urine tests → urinalysis**
   - pH >7.5 } infected stones or RTA
   - pH <5.5 } uric acid stones
   - sediment for crystalluria

   → **urine C&S** (urea-splitting stones suggest struvite stones)
   → **qualitative cystine**
5) imaging → KUB
   - radiolucent ("U Don't See The Xray IMAGE") } uric acid, xanthine, triamterene, etc
   - radio-opaque } Ca oxalate, Ca PO4, struvite [Mg ammonium PO4], cystine

   → IVP (radiolucent stones, anatomic abnormalities)
   → noncontrast spiral CT
   → renal function if thin parenchyma
6) stone analysis

Specific (Extensive) metabolic evaluation:

not done often

Indications:

1. Recurrent stone former
2. High risk single stone former

Includes:

- involves 2 visits
  - stop gill meds that could interfere with Ca. uric acid or oxalate metabolism (Vit D. Ca supplements. antacids. diuretics. acetazolarnide, Vit C)
  - stop all stone treatment meds (thiazides. P04. allopurinol. Mg)

- get three 24-hr urine samples:
  - 2 on a 1st visit (usual diet), 1 on 2nd visit (Ca-. Na-. and oxalate-restricted diet), discard first AM void, and collect for 24 hrs

    - check urine creatinine to validate collection
      men 15-20 mg/kg/day, women 10-15 mg/kg/day

- bloodwork :
    - CBC, lytes, BUN, creatinine, intact PTH, Ca, uric acid each visit

- urine tests:
    - pH, lytes, total volume, oxalate, citrate, qualitative cystine (each visit)

- **fast and Ca load test**:
    - urine collection done on morning of 2nd visit
    - helps to differentiates b/w absorptive, renal leak & resorptive hypercalciuria
    - How to do it:
        - restricted diet for 1 week prior
        - distilled water 12 hrs and 9 hrs prior
        - fasting for 12 hours prior
        - empty bladder completely 2 hours before calcium load and drink 600m L distilled water
        - Collect all urine during next 2 hours *(fasting urine)*
        - ingest **1g oral calcium load** in **250mL solution** over 5-10 minutes
        - urine collected over next 4 hours *(post-load urine)*
        - compare urine for excreted calcium .

NOT done very often because treatment for both absorptive and renal leak hypercalciuria are similar ... But essentIal if planning on prescribing Ca-binding resin for absorptive hypercalcuria

Urine sampling

قراءة سريعة للشفوي

- Two consecutive **24-h urine samples:** (Specific met. Evaluation)
  Technique:
    - bottles prepared with 5% thymol in isopropanol or stored at $\leq$ 8°C during collection (with risk of spontaneous crystallisation in the urine)
    - Examine immediately or add boric acid (10 g powder per urine container).
    - Urine pH should be assessed during collection of freshly voided urine four times daily using sensitive pH-dipsticks or ph-meter.
    - HCl (preservative)→prevent precipitation of calcium oxalate and calcium phosphate.
        - Disadv: inaccurate PH measurement and uric acid precipitates immediately.
        - Alkalinisation is needed to dissolve urate crystals if urate excretion is of interest.